VEDIC ASTRONOMY

(Vedaanga Jyotisha)

(OF LAGADHAACHARYA)

यथा शिखा मयूराणां नागानां मणयो यथा ।
तद्वद्वेदाङ्गशास्त्राणां ज्योतिषं मूर्धनि स्थितम् ।।

Like the comb on the head of a peacock or a jewel on the head of a snake, this scientific composition of Jyotisha (Vedic Astronomy) occupies, the apex position at the top of all (six) annexures of Vedas.

- Lagadha Mahaamuni

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FOREWARD

Shri Babasaheb Apte Smarak Samiti has published a few books which are based on research carried out with the objective of investigating our true history. We have now the pleasure in publishing this book which is a part of the same series. The Samiti was founded in 1973 to prepetuate the cause to which the late Babasaheb devoted a major portion of his life viz. investigating and writing the true history of Bharat. History which is at present taught in educational institutions is either written by English scholars or by persons under their supervision or influence.

Late Umakant Keshav Apte in whose memory the Samiti has been formed was called Babasaheb by his friends and wellwishers. A brief life-sketch of Shri Babasaheb Apte is given below. He was born in 1903 and lost his father in 1919 and served as a school teacher from 1920 to 1924, but resigned his job, when he was not allowed to tell stories of patriots to his students. In 1926, he came in contact with Dr. K.B. Hedgewar, the founder of Rashtriya Swayamsevak Sangh, who inspired him to dedicate his entire life to R.S.S. work. He became a pracharak (full time organiser) in 1931 and worked as such till his death in 1972.

Shri Apte's life was one of ceaseless activity in the pursuit of knowledge that can be compared to that of our ancient seers. Bharat was his venerable God and he inspired thousands of R.S.S. Swayamsevakas to follow his example. Every year he toured the entire country and awakened patriotism in the hearts of the people by his inspiring speeches. He was a orator, having an extra-ordinary command over Hindi, Marathi, Bengali and English. Though he began to learn Sanskrit in his middle age, his studious efforts not only helped to gain a command over that language, but also enthused and inspired others to follow suit. It was with his inspiration that two Sanskrit periodicals, Bhaaratee from Jaipur and Bhavitavyam from Nagpur were started and are being continuously published.

Shri Apte was a prolific writer and contributed innumerable articles on social, historical and cultural topics. In 1928, he wrote and published the biography of Punjab Kesari Lala Lajapat Rai and in 1930 that of Shilpa Kalaanidhi K.N.Vaze. His book entitled 'Raastrajeevana Kee

Paramparaa' published in 1950, highlights the stories of Dashaavataaras (regarding the incarnations of Lord Vishnu) presenting a well-knit picture of the continuous development of our national life.

Shri Bhanupratap Shukla, a renowed Hindi writer, collected and published in Hindi in 1980 the various articles of Shri Babasaheb in a book entitled 'Mrtyunjaya Bhaarata' (Immortal India). The title of the book gives a glimpse of the thinking of Shri Apte. Over the last 2,000 years, our country is facing foreign invasions of all types, but Bharat has survived them. We have many examples in the world history which show that many mighty empires and civilizations were completely destroyed by such invasions. The reason of this longevity and tenacity, according to Shri Babasaheb, lies in our long past glorious history, dealing with every facet of our national life. Every nation is naturally proud of its history and culture and it is no wonder that Bharat with its hoary past and with perhaps the longest unbroken cultural tradition in the world, should be justly proud of its heritage.

Late Babasaheb Apte was not only proud of our history but was also an ardent scholar who stressed that a proper study of our glorious past would tremendously help us in building a bright future. He often pointed out that the non-presentation of our entire national history embracing simultaneously all spheres of our national life and all parts of the country in a very small compass was essential. He put in the best of his efforts to inspire many to get rid of this historiographical drawback, but unfortunately could not remove it during his lifetime.

The need for compiling the history of Bharat, which embodies all facets of our national life, is now being undertaken it. In order to offer a befitting homage to the revered soul, the Shri Babasaheb Apte Smarak Samiti resolved to compile a history of our country since the commencement of Kali yuga. The Samiti feels that ths gigantic and indispensable national task can be fulfilled only by establishing district-wise centres under the able guidance of scholars interested in this subject. Since the last twelve years with the active co-operation from many scholars, the Samiti has been able to give some elementary shape to the scheme. The present book is one more step in this direction.

A through knowledge of various calendars in our history is essential to students of history to enable them to accurately determine dates and time of several epoach-making events and place them in proper chronological order. In 1986 Shri P.V. Alias Balasaheb Holay wrote a book in Marathi "Vedaanga Jyotisha" dealing with Indian Astronomy and calendar in January 1989 by the Samiti. Further research in the astronomical aspect of Vedaanga Jyotisha, and its calendrical system, have been carried out in the last five years by him especially on time reconing in Prevedanga period. We have therefore a complete chain of systems calenders from Yugaabda period i.e. from about 3200 B.C. to the invasion of Greeks on India.

The Vedaanga text is precise, almost like a mathematical formula. Later, however, because of centuries of non-use, it became incomprehensible. After years of painstaking research and penetrating analysis of its archaic Sanskrit, Shri Holay has succeeded in unrevealling its secrets. It will be a powerful key to resolve many perplexing riddles of chronology. We hope his work will inspire many present and future workers in this vast field.

Our organisation is a public charitable trust, publishing works of historical research which need a huge investment. In the publication of this book. Sau. Rajanitai w/o Vidyadhar Chitale, Sau. Rohinitai w/o Ashok Chitale, Sau. Suhashtai w/o Prabhakar Mundale, Shri Ramachandra G. Modak, Ku. Vimal H. Harakare in the memory of her brother late H. N. Harakare the trustees of late Sumati Deo Charitable trust especially Shri Vasantrao Deo and Annasaheb Udhoji advanced donations in cash and kind to us at different stages of printing and publication, I for myself and for Babasaheb Apte Smarak Samiti acknowledge their aid with a sense of gratitude.

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PREFACE

The pages of the history of ancient astronomy began with designing of instruments to measure time and speed, recording the speeds of motions of the sun, the moon and the planets, preparing a proper calendar to measure the exact length of the day, month, year and fixing of their ratios. One of the earliest books, or perhaps the first book is 'VEDAANGA-JYOTISHA' commonly called as "Vedaanga" written by an unknown author to describe the most accurate luni-solar calendar designed by the great sage Lagadha. Various civilisations made such an effort and failed. The modern calendar which we use is only a solar calendar, which rectifies the defect in earlier efforts. VEDAANGA-JYOTISHA was used as a hand-book by Vedic priests to know the positions of the sun and the moon on a particular future day. It comprises some formulae, which due its antiquity become unintelligible in the past.

An astronomical problem of 'dropping a lunation (Kshaya maasa) and inserting a compensatory intercalary month came up before Hindu almanographers in 1983. On the occasion the author of this book wrote an article in the 'Maharashtra Times' suggesting a luni-solar calendar based on the 19-year luni-solar cycle. Comparative tables of lunar year and tropical year were required to be prepared on the said occasion (Please see appendix 1 A & B). The author was aware that the interpretation of Vedaanga was an unsolved problem. A study of the same and revising the interpretation of the shloaks it was found that the Rik-text of the 'Vedaanga' is based on a 19-year luni-solar cycle. The author therefore wrote a book in Marathi which was appreciated by the authorities of Birla Planetarium of Hyderabad, who invited him as a guest speakar in a seminar of Ancient Indian Astronomy held in January 1987. The participants at the seminar expressed their desire to have a book in Hindi and English.

The author thereafter wrote the English edition of Vedaanga Jyotisha i.e. "VEDIC ASTRONOMY" and requested the President of Shri Babasaheb Apte Samiti, respected Moropant Pingley to publish it. He was kind to publish the first English version in January 1989.

The Rik-text of Vedaanga Jyotisha was matter of pride of the whole world community. It informs how carefully man observed the astronomical objects in the sky in third millenia B.C. and could make rules to predict their positions. Till the author wrote his Marathi and English book on the subject it was believed that both Rik and Yajus text of Vedaanga Jyotisha were based on 5-year luni-solar cycle. When it was revealed that the Rik-text of Vedaanga can only be interpreted on the basis of 19-year luni-solar cycle (commonly known as Metonic-cycle) a keen interest rose amongst scholars to study the Rik-text of Vedaanga in new light. The author expressed his views on the subject at several conferences of national and international importance held at Calcutta, Hyderabad, Bombay etc. The discussions held has necessitated the publication of a revised edition on the subject.

We have heard objections with extreme views on the subject. The first objection is that the astronomical cycle on which the Vedaanga calendar is based is only quinquinial cycle and not as we have found a 19-year luni-solar cycle. When we convince the objector that the base of "Vedaanga" is of 19-year cycle, he then says that its origin must be Babylonian. We were therefore required to trace out the history of development of various calenders in India in Pre-Vedaanga period. Fourtunately we could find evidance to show that Vedic sages divided the ecliptic in 3339 divisions called Bhaamshaas. These Bhaamshaas form a basic unit for the 19-year luni-solar cycle in Vedaanga. We also found that verse 13 in Rik-text of Vedaanga presumes in first 18 year of the cycle have a length of 365 days 126 Kallas (i.e. 5 hours) and the last i.e. the 19th year is leap year with a length of 366 days so that the average length of the year is adjusted as 365.25 days. In this edition we give Pre-Vedaanga calender system and Pre-Vedaanga nakshatra system used by Vedic sages.

We have assessed the antiquity of Rik-text of Vedaanga Jyotisha by astronomical calculations as 24th century B.C. Before the introduction of Rik-text of Vedaanga for Vedic rituals, Vedic sages used Daakshaayaniya (दाक्षायणीय) calendar with 95-year luni- solar cycle. Its details as given in Satapatha Braahmana are give in this edition.

The first verse and the 32nd verse of Rik-text of Vedaanga are ambiguous. They create a impression that the base of the astronomical calculations in Rik-text of Vedaanga is a 5 year luni-solar-cycle. These verses have misled eminent scholars for the last 2500 years. We therefore in this edition give some rules of interpretation of documents which are usually used in courts of law. We have also provided a separate chapter for interpretation of these ambiguous verses.

I feel it necessary to express my gratitude towards Dr. K.D. Abhyankar of Usmania University, and Ex-President of Astronomical Society of India, who took keen interest in the subject from the time of the publication of Marathi edition of the subject in 1986. Dr. S.D. Sharma of Patiala University, Shri B.B. Thite of Poona and Shri Vasantrao Deo of Nagpur made constructive suggessions in interpreting its mathematical aspects. Interpretation of Vedaanga Jyotisha is a subject of joint discipline. Astronomy and Sanskrit are its the basic subjects. I am obliged to sanskrit scholar Dr. K.R. Joshi and Shri N.G. Baitule with whose help I could make efforts to give proper explaination of the sanskrit words in the text consistant with astronomical rules. Inspiration was also provided by Dadasaheb Chitale, Bhayyasaheb Mundale and Annasaheb Udhoji of Nagpur. I am grateful to all of them.

When the first English edition of the Vedic Astronomy was published Maananiya Moropant Pingley the President of Apte Samarak Samiti expressed that the knowledge of various calendar systems in India after Yugabda i.e. 3102 B.C. was necessary for the Samiti for establishing the historical dates of events from the beginning of Kali Yuga. When he knew that the revised text on the subject is ready he asked the Samiti to undertake the work of printing and publication. Shri Prabhakarrao Faizpurkar the Secretary of the Samiti took keen interest in the work. Two editor members of the Samiti Shri Anant W. Vyavahare and Shri Gangadhar P. Deshmukh scrutinised the text and made valuable suggestions. I am greatful to Mananiya Moropant Pingley and the team of the aforesaid workers of the Samiti for printing and publication of the book.

We have used number of tables to explain the contents of Vedaanga Jyotisha to minimise the use of mathematical equations, so a layman may understand the interesting subject. We think we have achieved the object.

Nagpur
Date : 13-10-1994
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Sr.No.	Name of the book	Abbreviations
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2.	Its English Translation by H H. Wilson	H.H. Wilson
3.	Taittriya samhita	Taitt. Sam.
4.	Taittriya Braahmana	Taitt. Br.
5.	Aitreya Braahamana	Ait. Br.
6.	Shatapatha Braahamana	S. B.
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25.	Astronomical method and its applications to the chronology of ancient India Dr. K.L.Daftari	K.L.Daftari

PRONUNCIATION

Sanskrit	English	Instance
अ	a	As in infant
आ	aa	As in far
इ (अि)	i (short)	As in pin
ई (अी)	ee (long)	As in deep
उ (अु)	u (short)	As in put
ऊ (अू)	oo (long)	As in moon
ऋ	ri	As in triune & ruin
		As in pen
ए (अे)	* e	As in dine
ऐ (अै)	* ai	As in bone
ओ	o	As in house, mountain
औ	au	depending upon the consonant that
अं (-)	am or an	follows.*
		visarjaneeya (in-take of breath)
अः	aḥ	

Consonants

Velar	क	ख	ग	घ	*(ङ)
	K	Kh	g	gh	ŋ
Palatals	च	छ	ज	झ	*(ञ)
	Ch	Chh	J	Jh	
Cerebrals	ट	ठ ड	ढ	ण	
	t̲	t̲h̲	d̲	d̲h̲	n̲
Dentals	त	थ	द	ध	न
	t	th	d	dh	n
Labials	प	फ	ब	भ	म
	p	ph	b	bh	m

Semi Vowels

य	र	ल	व
y	r	l	v or w

श	ष	स	ह	ळ	ज्ञ	क्ष
sh	sh	s	h	l	jn	x or ksh

* **Note :** Letter n is used for anusvaara. No separate pronuciation mark is used for * & * because these nasals are rarely followed by vovels. The consonants that follow them govern their pronuniciation (as Velars or Palatals) e.g. Vedaanga * or *, Pancha * or * . This rule itself is sufficient as guide for their pronuciation. If the consonant that follows is labial, anusvaara as m.

PART - I

CHAPTER - 1

History of Ancient Vedic Astronomy and Calendars

European world knows the story of Robinson Crusoe. He was forced to land on an unknown island and live like a civilian. For remembering days and dates he prepared a calendar by marking the stump of a tree. He named his tribal servant as Friday. In India there was a time when people, did not require any artificial means to remember days and dates, provided the citizen could have a look at the moon in the clear sky. They used the most natural calendar. They could find out the month in a year by looking at the eastern horizon after dusk and by indentitying the star or the constellation that was rising and could tell the date by observing the phase of the moon. The day was named according to the asterism (nakshatra) or the small constellation which the moon covered on the relevant day. Had a vedic priest been in the same situation as Crusoe, he could have told the number of years, months and days after he left his house, if he could see the sky, and the moon, and if he could fix the longest day by looking at the shadows at mid-noon. This is because of the work of the great Indian astronomer sage Lagadha, whose work is a subject matter of this book. At the initial stages most of the civilizations of the world made efforts to follow natural calendars. The history of ancient calendars is relevant to our subject. C.V. Vaidya has narrated the history in the following words :

'Lunar months can be noticed from two consecutive full moons. A year can be noticed from the cycle of the seasons. On a rough scale twelve lunar months constitued a year, but their proper relation could not be found out by earlier civilizations. This created confusion and difficulties. To come over this confusion, the Arabs ignored the solar cycle and followed a year consisting of twelve lunations. At present Muslims regard this interval as a year. Their year revolves through all seasons and (after 32 1/2 years) gets back to the original position.

The Romans used to count ten months from the month of March, thereafter left some days uncounted, and began with a fresh year with full moon in the spring season. Several years thereafter, king Numa introduced the custom of inserting 23 days at the interval of two years.

There were disputes between the religious heads on the point of time for introducing these 23 days. To avoid a confusion, Julius Caesar discarded the lunar cycle and introduced a solar year comprising of 365 1/4 days. He divided the year in twelve parts of roughly equal duration, and called them solar months. Greeks also tried to design a lunar calendar consistent with solar days. They completed the year in 354 days with twelve lunar months, alternatively consisting of 30 days and 29 days. But they missed the seasons. King Solan therefore tried to introduce an intercalary month to harmonise the lunar year with seasons, but he was unsuccessful. Egyptians knew that the year comprises of 365 days. They divided the year in twelve months consisting of 30 days each, and added 5 days at the end of the year. Yet the seasons rotated in a cycle of 1460 years due to a mistake of about 1/4 day in a year, because 365 × 4 = 1460. Modern astronomers call the period of 1460 years as Sothic cycle. Parsis also added 5 days after an interval of 360 days to constitute a year of 365 days.

Jews, at present, use a luni-solar calendar based on the 19-year cycle. This cycle was introduced in the 4th century of the Christian era. It provides for addition of intercalary months at the intervals of 3, 6, 8, 11, 14, 17 and 19 years. The intercalation is made in the months of Adar (Feb-March). The British Encyclopaedia states that the present knowledge of the pre-exile Jewish calendar is limited and uncertain. Both the testaments of the Bible, the Old and the New, refer to calendar matters sparingly.

In China, Shang civilisation could find out a solar year of 365 1/4 days and the lunation of 29½ days by about 14th Century. B.C. They added a 13th month in the lunar year intermittantly. They could know about the 19-year luni-solar cycle consisting of 235 lunations about a century before Meton could find it out. They divided the ecliptic path of the Sun, the Moon, and the planets in 24 divisions. The Sun was presumed to travel each division in 15 1/4 days. For the purpose of naming these divisions, 24 stars were selected. They called this luni-solar calendar as Yin-Yang-li. Their method of intercalation was the same as the one introduced by Varaahamihira in the present Hindu calendar. Thus though the Chinese knew the 19-year astronomical cycle, they did not use it in calendars.'

Encyclopaedia Britannica gives an interesting history of calendars. It states that in Babylonia it was necessary for the lunar year of about 354 days to be brought into line with solar year of approximately 365 days which determines the growth of vegetation. This was accompanied by the use of a intercalated month. Thus in the 21st century B.C. a special name for the intercalated month *'iti diring'* appears in sources. The intercalation was operated haphazardly according to real or imagined needs and each Sumerian city intercalated months at its will. In 380 B.C. Babylonian calendar calculators succeeded in computing an almost perfect equivalence in a luni-solar cycle of 19 years and 235 months with intercalations in the years 3, 6, 8, 11, 14, 17 and 19 of the cycle." (Ref. : page 605. Enc. Br. on Calendars.)

"The main use of cycles was to try to find some commensurate basis for lunar and solar calendars and the most famous of all the attempts was that usually attributed to Leostratus (500 B.C.) and Endoxus of Cnidus (390 - 340 B.C.) often known as the *Octacteris*. The cycle covered 8 years as its name implies and since the 6th cen. B.C. the year was accepted to be 365 days in length, the *octracteris* amounted to 365 × 8 i.e. 2920 days. This comes close to the total 99 lunations 99 × 29.5 = 2920.5 days" (see page 597 Enc. Br.)"

About the Greek calendar, it says "Astronomers such as Meton who in 432 B.C. calculated a 19-year luni-solar cycle were not heeded by the politicians, who clung to their calendar-making power". (page 605-606 Enc. Br.).

Other nations have used arbitrary time cycles for preparing calendars, as e.g. a 15-year cycle in view of a custom of making accounts of collected tax, or a week of seven days. This has no relevance with the speed of astronomical bodies.

It is worth-while to give here a brief history of the development of calendars in India, excluding detailed evidence. In India, the lunar and the solar cycles had a specific importance in cultural and spiritual development of the Vedic people. They worshipped God *Indra* for a successful harvest. They depended on the monsoon cycle of rains for cultivation. *Indra* was their deity. They presumed the place of *Indra* near the rising star on the eastern horizon, which they saw immediately after dusk (i.e. practically 180° away from the Sun). For them the Moon was a pot carrying Soma juice which gets filled every day. After getting completely filled, it touched the lips of *Indra* and his friend, one of the six *Aadityas* (i.e. the deities of the seasons) on the full-moon day. (see Tait. Sam. 2-4-14)

यमादित्या अंशुमाप्यायन्ति

यमक्षितमक्षितयः पिबन्ति

and also Rik Sam. X. 85-5

यत्त्वा देव प्रपिबन्ति तत आप्यायसे पुनः ।
वायुः सोमस्य रक्षिता समानां मास आकृतिः ।।

They thought, whatever Soma juice they offered as oblation to the fire god, gets accumulated in the Moon-pot on a giant wheel, which takes it to Gods for a drink. If they were to continue their sacrifices with this concept, it was necessary for them to find out a proper relation between the solar cycle of six monsoon seasons and the lunar cycle.

Their early method of harmonising the two cycles was introduced by an astronomer *Shunahshepa*. It was visual, similar to that of Imams, who declare Id for muslims. The path of the Sun, the Moon, and the planets on the background of the stars is known as the ecliptic path. Vedic citizens named a fixed star on the ecliptic as *Varuna*. They counted the number of full moons which appeared at various points, one after another throughout the year from the eastern side of the star of *Varuna*. They found that the full moon usually appeared at various twelve places before completing the cycle. It was found that sometimes there were 13 points in the sky, where the full moon appeared at successive intervals before completing the *Varuna* cycle. They therefore counted 13 months in that year. The 25th hymn of the first *mandala* of the Rig Veda is composed by *Shunhshepa* in praise of the deity *Varuna*. The 8th verse of this hymn is translated by H.H. Wilson thus :

"He, who accepting the rites (dedicated to him), knows the twelve months and their productions, and that which is supplementarily engendered."

From Rik X. 147 *Yama antyeshti* hymn, the place of *Varuna* can be located as a star on the cross-lines of the milky way and the ecliptic near two dogs *Canis Major* and *Minor*, most easy visual method without involving any calculations. We have explained the same with the help of a figure in Appendix-II.

Students of astronomy call the star's year cycle, like that in the *Varuna* cycle, as sidereal year. The cycle of seasons i.e. the tropical year receeds by one day in a period of 72 years with respect to the sidereal year. The difference is so small that it could not be noticed in those days.

The Vedic priests started their sacrifices on a full moon day immediately after a rainy season i.e. in autumn (or some times eight days prior to such a day). Summer rains have a duration of 2, 3 or 4 months, depending on the location of the place in India. The sacrifices therefore continued for 9 to 10 months. The priests who performed the sacrifices were consequently called *Navagva* and *Dashagva Angirasas*.

The rotation of the seasons with respect to the stars was very slow. It could not be noticed in the beginning, but when the difference increased after about 2000 years, the predictions of the priests about the time for the commencement of rains were found wrong.

Ashvini brothers, who were also called *Naasatyas*, found out by an ingenious method the time of commencement of the summer rains. They observed the image of the Sun in a well at mid-noon in summer. They found that the Sun which started climbing the sky from the south in the winter season reached zenith. If we were to give corresponding dates in modern European calendar, we would say that the Sun reached the zenith on the 18th of June, went towards the north, and returned back to the zenith again on the 26th of June. *Ashvinis* could therefore fix the date of the return journey of the Sun towards south, which we now call the longest day or a day or Summer Solstice (i.e. 22nd June). The probable date of the commencement of summer rains could be fixed with respect to this day, depending upon the location of the relevant place. From the interval of 9 days journey of the Sun as observed by the *Ashvinis*, we can locate the place of their experiment. It was about 10 kilometers towards south of the tropic of cancer.

Other Vedic astronomers, known as *Ribhu* brothers, took advantage of *Ashvini's* experiment and counted the number of days in a solar year. They divided the year in four parts. *Aitareya Braahmana* gives the calendar which is practically the same as the one designed by *Ribhus*. Their calendar consisted of 12 solar months of 30 days each. They allotted 2 days for Summer Solstice (i.e. 22nd of June) and called them a *Rathantara Saaman*. At winter solstice, 3 days were allotted for *Brihat-Saaman* (i.e. big Saaman). The word *Rathantara* means changing a chariot. The Sun was presumed to change his chariot for return journey towards the south. Vedic astronomers used to observe the image of the Sun in a well during these days and adjust the duration of the *Rathantara Saaman*. Usually it was 2 to 3 days between the interval of four years. The custom of observing the image of the Sun during Summer Solstice is given in *Asya-Vaameeya Sookta* i.e. Rik 1-164-25. The solar calendar is described as *Aadityaa naama ayanam* in the *Aitareya Braahmana*. According to this solar year, sacrifices were to commence on a day of autumnal equinox i.e. the 91st day from Summer Solstice. This day was called *Aarambhaneeya* day. The author of the *Aitareya* compares *Rathantara* with the change of a ship at the shore for return journey. He gives a warning not to miss it or combine with the *Brihat Saaman*, otherwise the sacrifices would begin at any time i.e. in any season (Ait Br 17.7.4). Here the relevant fact for our subject is that the Vedic astronomers could find out the day of the Summer Solstice very correctly. It is worthy of note that the image of the Sun in water in a well is more sharp than the shadows of sticks which were usually used for fixing the dates of summer and winter solstices. These shadows were always accompanied by *pen-umbra*. Another relevant fact to be brought to the notice of readers is that the Vedic priests knew the importance of dividing the tropical year at 4 proper points, the knowledge of which is a condition precedent to deriving the *Vedaanga cycle* and preparing a calendar.

The search for an accurate tropical solar year also could not solve the problem before the Vedic priests, because it had no relevance with the phase of the moon. For some of those priests, worship of *Indra* was obligatory, because their concept of the moon as a pot filled with Soma juice for offering to the *Aadityas* could not be erased easily. Moreover, it would have been found difficult to have experimental observations to fix the date of the Summer Solstice throught India. It was, therefore, necessary to search some method to predict the Summer Solstice and the Winter Solstice. The best method was to fix their positions in a lunar calendar with respect to a lunar month and a lunar date. They therefore started to find out a time- cycle, which would create harmony between the solar and the lunar cycles. Sidereal positions of the sun and the moon were therefore observed for thousands of years. A 95 year-cycle was found out by the priests during Shatapatha Braahmana times. Its details are given in this book. Ultimately the Vedic sage Lagadha discovered the 19 year cycle. He also gave rules to prepare a good natural calendar. The rules are given in the form of verses attached to the *RigVeda* as one of the six appendices.

A Vedic priest has to learn by heart the text of the Vedas which is called *Samhitaa along with its appendices. These are called Shadangas*, which consist of six different subjects, the knowledge of which is necessary for conducting sacrifices, *Jyotisha* i.e. astronomy is one of them.

A Vedaanga calendar presumes the point of Summer Solstice near the star *Regulus*. The gradual precession of summer Solstice was not known to earlier civilisations. Various luni-solar calendars were therefore designed and discarded before and after the composition of the present text. Some different cycles were also tried, and as a result, the religious Vedaanga calendar differed from other official calendars. In the 5th century A.D. an eminent Hindu astronomer *Varaahamihira* introduced a meteorological cycle with 12 points located at equal distance in the sky called *Sankraantis* with corresponding days when the Sun covers those points. The lunation was named according to the *Sankraanti* day that occurs in the lunation. Occasionally we have a lunation in which there is no *Sankraanti* day; that lunation is called *adhika maasa*, an intercalary month. *Varaahamihira* used Greek names for the 12 divisions of the ecliptic path.

As a result, the religious calendar *Vedaanga Jyotisha* went out of use, though it was preserved for reciting as a religious procedure.

If we do not mention here the name of the Vedic astronomer "Archan Hiranyastoop", this book on Vedic Astronomy would remain incomplete. Lokmanya Tilak has assessed Vedic antiquity to be more than 6000 years. This is a most moderate assessment. Archan Hiranyastoop who lived in a remote antiquity could imagine solar gravitatioal fetters holding the earth operating through the indestructible medium ether. We get it in the tenth Mandala of the Rigveda. Following is the translation of Rik. verse X. 149.1 by H.H. Wilson -

> "Savitri (Sun) has fixed the earth with fetters. Savitri has made the heaven firm in place where there was no support. Savitri has made the cow of the firmament bound to the indestructible (ether) like trembling horse."

Greek astronomer Aristorchus also thought of a heliocentric model of the Universe. The theories of Archan-Hiranyastoop or of Aristorchus were not based on any firm mathematical foundation. Recent astronomers Copernicus and Newton have advanced their theories in a more convincing form with mathematical details. We do not expect astronomers of remote antiquity to be so exact. Yet the history of astronomy has to begin with their names. However, this book deals with the work of Sage Lagadha who found out the 19-year luni-solar cycle and designed a calendar accordingly.

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CHAPTER - 2

Modern Probe

Lokmanya Tilak has used the word 'Vedaanga' for his text. Let us use the same. Vedaanga is the oldest text on astronomy. This text is a hand-book used by Vedic priests. It therefore presumes that its readers have some knowldge about the then existing practices, e.g. (i) it refers to only 2 names of lunar-months i.e. *Maagha* and *Shraavaṇa* and expects from its readers knowledge of other names. (ii) just as in chemistry we denote an element by a symbol (e.g. H for hydrogen), Veddanga gives symbols for 27 asterisms (*nakshatras*) on the ecliptic path. Some symbols are derived from names of asterisms and others from names of deities concerned. (iii) it narrates some formulae using some numbers, but does not give what the numbers are about i.e. years, months or days and expects from its readers knowledge of the Vedic practices for their calculations (e.g. verse 4). With all these deficiencies, the text is preserved for thousands of years because of its religious and sentimental importance. It had become unitelligible.

There are six appendices to the Vedas. Jyotisha is one of them. All the six appendices of the Vedas are treated as sacred as the Vedas themselves. They were reproduced or recited for religious purposes even without understanding their meaning. Late Mr. S.B. Dixit says that any effort to suggest an amendment or correction was opposed by Vedic Brahmins. Yet in all parts of India, the text is meticulously reproduced in the same manner with all its supposed defects.

Lokmanya Tilak says that "the tract appears in two forms, one belonging to the RigVeda and the other to YajurVeda.." The first was published by Captain Jarvis at the end of "Indian Meteorology" in 1834, Prof. Weber brought out in 1872 a critical edition of both the recensions with various readings collected from manuscripts then available to him. He further adds: "Dr. Thibaut, in his essay on the Vedaanga, which appeared in the Journal of the Asiatic Society of Bengal, 1877, was the first to decipher a few difficult verses, and among others who followed him the name of Shankar Balkrishna Dixit deserves to be equally mentioned".

A commentary on the *Yaajusha* text of the Vedaanga is composed by Somaakara. S.B. Dixit says that Dr. Thibaut could decipher six more verses than Somaakara and adds that in 1881 he had translated all such verses in Marathi, the meaning of which was then known to him. Krishnashastri Godbole also tried to decipher the Vedaanga, but he could not explain more verses than were already explained by Dr. Thibaut. In 1885 J.B. Modak printed a Marathi translation of both the texts of the Vedaanga. He explained 2 or 3 verses more than what Dr. Thibaut did.

There are in all 36 verses in Rik text and 43 verses in Yajur text. 36 verses are practically common to both, and therefore there are in all 36 + 13 = 49 verses. Dixit has given a table of comparative numbers in his Marathi book on the History of Indian Astronomy. Dixit stated that he had deciphered 9 more verses. There is also a third text known as *Atharva Jyotisha*, but it deals mostly with astrology than astronomy. As such it is not a subject matter of this book.

Lokamanya Tilak says : "The French astronomer Bailey in his treatise on Indian Astronomy published in 1786 had assigned a very high antiquity to the Indian Science; and it was to refute this view that Bentley published his Historical View of Indian Astronomy in 1823. Bentley thinks that in times of Akbar the Great, in order to impose upon the Emperor, many of the ancient theories were in reality composed or fabricated." Sir William Jones and Colebrooke, who held opposite views, gave a sharp reply to Bentley. Bentley's view was subsequently rejected by all scholars. Lokamanya Tilak has mentioned that Prof. Whitney, who edited and published the translation with notes under the auspices of the American Oriental Society in 1860, has not a word to say in favour of the Indian astronomers, whom he considers incapable of originating any scientific theory or making even tolerably accurate observations. He has, therefore, come to the conclusion that the Indians were wholesale borrowers in this respect."

Lokamanya Tilak, while writing a book "Vedaanga Criticisms and Suggestions" has taken into consideration the works of Lala Chhotelal (*nom de plume* Baarhaspatya) and Mm. Sudhakar Dvivedi (Sudhaakara *bhaashya*, 1903) and explained Rig verses 10, 11, 13, 19 & 21 along with other verses in the Yajus recension. He presumed that the yuga or the luni-solar astronomical cycle in Vedaanga was of 5 years, and therefore could not decipher the Rik verses properly. He also acceptrd interpretations given by earlier workers in respect of verses 1,4 and 8 to be correct. According to me the astronomical cycle in Vedaanga is of 19 years, which was discovered by the Vedic astronomer Lagadha. This cycle was also subsequently discovered by the Chinese in the 6th cen. B.C. and a Greek astronomer Meton in 432 B.C. Meton's cycle was known to Vedic astronomer *Lagadha Maharshi* atleast 2000 years before Meton knew it. *Maharshi Lagadha* did not stop at discovering the cycle, he made rules for an ideal calendar. His calendar can be understood by an illiterate person by looking at the moon and the stars in the sky. He mentioned in verse Rik 30 of Vedaanga that his calendar accords with the reading of the heaven (लोक) by the people(लोक) .

सोमसूर्यस्त्रिचरितो लोकाँल्लोके च संमितं ।
सोमसूर्यस्त्रिचरितो विद्वान्वेदविदश्रुते ॥३०॥

"The sun and the moon have three motions in the heaven known to the people. The sun and the moon have three motions known to the learned (priests) who knew the Vedas (i.e. Vedic Sacrifices)."

I have gone through a booklet on *Vedaanga Jyotisha* by Kaavyateertha Vaachaspati Dr. Himmatram M. Yajnik of Ahmedabad. In the introduction to his book he mentions the names of earlier scholars like Lokamanya Tilak, and further adds that Dr. M.M. Pandit Sudhakar Dvivedi and R. Shyaama Shastri have contributed to the subject. Even after reading these interpretations, he comes to the conclusion that "Yajus *Jyotisha* is mostly an enlarged and corrected version and more or less a supplement to the Rik *Jyotisha*". He then explains the Vedaanga *Jyotisha*, treating its Rik and Yajus recensions to be based on a 5-year cycle. In March 1979 Prof. T.S. Kuppanna Sastry of Madras, on the occasion of a workshop on Ancient Indian Astronomy organised by Bharatiya Vidya Bhavan, at Bombay, set out his exposition of *Vedaanga Jyotisha*, which was subsequently edited in August 1984 by Dr. K.V. Sarma of the Kuppannaswami Sastri Research Institute of Madras. This work was then published in the same year in a journal of Indian National Science Academy.

In Prof Kuppanna Sastri's book, he has made an effort to explain the yuga in both Rik and Yajus texts of the Vedaanga to be based on a 5-year luni-solar cycle. He has further published an amended edition of both these recensions. In 36 verses of the Rik recension he has suggested 39 emendations out of which 8 emendations are suggested in the verses touching the subject of yuga (Viz. verses No. 8, 9, 19, 20).

The important purpose of this work is to demonstrate how the number of synodical months i.e. lunations were systematically arranged in a luni-solar cycle by Vedic astronomers. We rely more on the unamended text of the Vedaanga. I am obliged to Dr. K.V. Sarma who has edited Prof. Kuppanna Sastri's book. He has given, in foot-notes, the difference between various critical versions of the Vedaanga in all manuscripts. The Rik recension from "Shadanga" printed by Nirnaya Sagar Press, Bombay, practically corroborates with the original recension excepting two changes in the 32nd verse of Rik- text (RVJ-32) as pointed out by S.B. Dixit. : RVJ - 32 included the words "Yugasya Panchamasyeh" instead of "Yugasya Panchavarshani". and "Nibodhat" for "Prachakshte" (प्रचक्षते) (See S.B. Dixit, Vol I, page 94.) S.B. Dixit points out these changes from Bhatothala's comentary on the subject - dating back to 966 A.D. Lok. Tilak has also given in his book the original text first and then the amendments suggested by him. We thus rely more on the text which was commonly used by Vedic priests in India.

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PART - II

वेदांगज्योतिषम्

(ऋक् पाठः)

श्रीगणेशाय नमः । हरिः ॐ ।।

पञ्चसंवत्सरमयं युगाध्यक्षं प्रजापतिम् ।
दिनर्त्वयनमासाङ्गं प्रणम्य शिरसा सुचिः ।।१।।
प्रणम्य शिरसा कालमभिवाद्य सरस्वतीम् ।
कालज्ञानं प्रवक्ष्यामि लगधस्य महात्मनः ।।२।।
ज्योतिषामयनं कृत्स्नं प्रवक्ष्यामनुपूर्वशः ।
विप्राणां संमतं लोके यज्ञकालार्थसिद्धये ।।३।।
निरेकं द्वादशार्धाब्दं द्विगुणं गतसंज्ञिकम् ।
षष्ट्या युतं द्वाभ्यां पर्वणां राशिरुच्यते ।।४।।

स्वरार्कमेके सोमार्कौ यदा साकं सवासवौ ।
स्यात्तदादियुगं माघस्तपःशुक्लो दिनंत्यजः ।।५।।
प्रपद्येते श्रविष्ठादौ सूर्याचान्द्रमसावुदक् ।
सार्पार्धे दक्षिणार्कस्तु माघश्रावणयोः सदा ।।६।।
घर्मवृद्धिरपां प्रस्थः क्षपान्हास उदग्गतौ ।
दक्षिणे तौ विपर्यस्तौ षण्मुहूर्त्ययनेन तु ।।७।।
द्विगुणं सप्तमं चाहुरयनाद्यं त्रयोदश ।
चतुर्थं दशमं चैव द्विर्युग्माद्यं बहुलेऽप्यृतौ ।।८।।

वसुस्त्वष्टा भगोजश्च मित्रः सर्पाश्विनौ जलम् ।
धाता कश्चायनाद्याश्चार्धपञ्च नभस्त्वृतुः ।।९।।
भांशाः स्युरष्टकाः कार्याः पक्षा द्वाटश चोद्गताः ।
एकादशगुणस्योनः शुक्लेर्धं चैन्दवा यदि ।।१०।।
कार्या भांशाष्टकास्थाने कला एकान्नविंशतिः ।
ऊनस्थाने द्विसप्ततीरुद्वपेदूनसंमिताः ।।११।।

त्र्यहंशीभशेषो दिवसांशभागश्चतुर्दशस्याप्युपनीतभिन्नम् ।
भार्धे ऽधिके चाधिगते परेंशे द्वावुत्तमैकं नवकैरवेद्यम् ।।१२।।

पक्षात्पञ्चदशाच्चोर्ध्वं तद् भुक्तमिति निर्दिशेत् ।
नवभिस्तूद्गतोंशः स्यादूनांशद्व्यधिकेन तु ।।१३।।
जौ द्रा घः खे श्वे ही रो षा
चि न्मू ष ण्यः सो मा धा नः ।
रे मृ घ्रा श्वा ओ ज स्तृ ष्वो
ह र्ये ष्टा इत्यृक्षालिङ्गैः ।।१४।।
जावाद्यंशैः समं विद्यात्पूर्वार्धे पार्वसूत्तरे ।
भादानांशाच्चतुर्दशी काष्ठानांदेविनाकलाः ।।१५।।
कला दश च विंशा स्याद् द्विमुहूर्तस्तु नाडिके ।
द्वित्रिंशस्तत्कलानां तु षट्शती त्र्यधिकं भवेत् ।।१६।।

नाडिके द्वे मुहूर्तस्तु पञ्चाशत्पलमाषकम् ।
माषकात्कुम्भको द्रोणः कुटपैर्वर्धते त्रिभिः ।।१७।।
ससप्तकुंभयुक्स्योनः सूर्याद्योनिं त्रयोदश ।
नवमानि च पञ्चाह्नः काष्ठा पञ्चाक्षराः स्मृताः ।।१८।।
श्रविष्ठाभ्यां गुणाभ्यस्तान् प्राग्विलग्नान्विनिर्दिशेत् ।
सूर्यान्मासान्षळभ्यस्तान् विद्याच्चान्द्रमसान् ऋतून् ।।१९।।
अतीतपर्वभागेषु शोधयेद् द्विगुणां तिथिम् ।
तेषु मण्डलभागेषु तिथिनिष्ठां गतो रविः ।।२०।।

याः पर्वभादानकलास्तासु सप्तगुणां तिथिम् ।
प्रक्षिपेत्कलासमूहस्तु विद्यादादानकीः कलाः ।।२१।।
यदुत्तरस्यायनतोयनं स्याच्छेषं तु यद्दक्षिणतोयनस्य ।
तदेक षष्ट्या द्विगुणं द्विभक्तं स द्वादशं स्याद्दिवसप्रमाणम् ।।२२।।
तदर्धं दिनभागानां सदा पर्त्रीणि पर्वणि ।
ऋतुशेषं तु तद्विद्यात्संख्याय सहपर्वणाम् ।।२३।।
इत्युपायसमुद्देशो भूयोऽप्येनं प्रकल्पयेत् ।
ज्ञेयराशिं गताभ्यस्तान् विभजेज्ज्ञानराशिषु ।।२४।।

अग्निः प्रजापतिः सोमो रुद्रोदितिर्बृहस्पतिः ।
सर्पाश्च पितरश्चैव भगश्चैवार्यमापि च ।।२५।।
सविता त्वष्टाथ वायुश्चेन्द्राग्नी मित्र एव च ।
इन्द्रो निर्ऋतिरापो वै विश्वेदेवास्तथैव च ।।२६।।
विष्णुर्वसवो वरुणोज एकपात्तथैव च ।
अहिर्बुध्नस्तथा पूषाश्विनौ यम एव च ।।२७।।
नक्षत्रदेवता एता एताभिर्यज्ञकर्मणि ।
यजमानस्य शास्त्रज्ञैर्नामनक्षत्रजं स्मृतम् ।।२८।।

इत्येतन् मासवर्षाणां मुहूर्तोदयपर्वणाम् ।
दिनर्त्वयनमासांगं व्याख्यातं लगधोऽब्रवीत् ।।२९।।
सोमसूर्यस्त्रिचरितो लोकाँल्लोके च संमितम् ।
सोमसूर्यस्त्रिचरितो विद्वान् वेदविदस्नुते ।।३०।।
विषुवं तद्गुणं द्वाभ्यां रूपहीनं तु षड्गुणम् ।
यल्लब्धं तानि पर्वाणि यथोर्ध्व सा तिथिर्भवेत् ।।३१।।
माघशुक्लप्रवृत्तस्य पौषकृष्णसमापिनः ।
युगस्य पंचमस्येह कालज्ञानं निबोधत ।।३२।।

तृतीयां नवमीं चैव पौर्णमासीं त्रयोदशीम् ।
षष्ठीं च विषुवां प्रोक्तो द्वादश्यां च समं भवेत् ।।३३।।
चतुर्दशीमुपवसतस्तथा भवेद्यथोदितो दिनमुपैति चंद्रमाः ।
माघशुक्लाह्निको युंक्ते श्रविष्ठायां च वार्षिकीम् ।।३४।।
यथा शिखा मयूराणां नागानां मणयो यथा ।
तद्वद् वेदाङ्गशास्त्राणां ज्योतिषं मूर्धनि स्थितम् ।।३५।।
वेदा हि यज्ञार्थमभिप्रवृत्ताः कालानुपूर्वा विहिताश्च यज्ञाः ।
तस्मादिदं कालविधानशास्त्रं यो ज्योतिषं वेद स वेद यज्ञान्
यो ज्योतिषं वेद स वेद यज्ञानिति ।।३६।।

पञ्च संवत्सरं प्रपद्येते कार्याः कला दश च याः
पर्वसविता विषुवं सप्त ।।इति वेदांगज्योतिषं समाप्तम् ।।

PART - II

CHAPTER - 3

What is a Yuga ?

A cycle of events in astronomy was called by Indian astronomers a 'YUGA' e.g. a cycle in which all planets Viz. Venus, Mars, Jupiter, Saturn etc assembled at one *nakshatra* (asterism on the ecliptic). The cycle of these yugas was considered quite big i.e. of about 4320 thousand years. Comparatively 'Lagadha Yuga' is very small. We should know the beginning of the tropical year and the lunar month before we know the duration of this yuga.

Initially the Vedic sacrifices began on the day of autumnal equinox. The corresponding date on the European calendar for this would be the 21st of September. Ashvinis and Ribhus had provided a method to find out the day for the beginning of such an year. It is called a tropical year. Another year is called a sidereal year or the year of the stars. The day of beginning of the year of the stars was fixed according to a star that rose on the eastern horizon immediately after dusk. There was a time when the year began with the rising of Maghaa (Regulus). Rising of full moon with Regulus was therefore treated auspicious and some priests began their sacrifices on this day.

Astronomers know that the year of the stars gradually starts with a late beginning. In this particular case, Regulus started rising in a season corresponding to October, then in November and subsequently in December. There is a difference of opinion among scholors about the day of rising of Regulus in the Vedaanga period. Majority of scholars including Tilak, Dixit, Kuppanna Sastri and Yajnik, presume that Regulus used to rise on or about the 22nd of December (Winter solstice) in the Vedaanga period, while Srinivas Raghavan and G. Sampat Ayyangar presume that it used to rise on a day corresponding to the 21st of September (Automnal equinox). We avoid discussion on this point and presume for explaining the subject that the Maghaas used to rise in Vedaanga period on the day of winter solstice i.e. a day corresponding to the 22nd of December.

In Vedaanga a lunar month begins with the new-moon. The Vedaanga Yuga began when the beginning of the year coincided with the beginning of the month, it ended when the end of the year coincided with the end of a month. In other words Lagadha yuga began on a day when a day of amaavasayaa (New Moon) coincided with *Uttaraayana* (winter solstice). The cycle takes 19 years to complete.

Vedic Astronomical Terms

A day and a night together is called a *dina* in Sanskrit. The same word is used in Vedaanga with the same connotation. A lunation or a lunar month has a length of about 29.530588 days i.e. roughly 29.5 days. Lagadha divided the month in subdivisions with round figures and called them 30 *tithis*. For a layman a tithi was practically a day. But it was shorter than a day by about 23 minutes. Hindus still use this unit of time for their calendar. We have thus two sets of units of time, solar and lunar units.

Solar year = 365.25 days.
Lunar year = 12 lunations (about 354 days)
Solar month = 1/12 year (about 30.44 days)
Lunar month = 1 lunation
Solar day = 24 hours
Lunar day = tithi = 63/64 day (in 19-year yuga)
61/62 day (in 5-year yuga)
(astronomically 29.530588 ÷ 30 days)

Zero tithi or the astronomical new-moon event being common to all parts on the globe is universal, unlike a day which is local, dependant on the time of Sun-rise and the mid-noon. As the path of the Moon around the earth is not perfectly circular, nor the path of the earth around the Sun, but they are elliptical, all tithis and lunar months in the year are not equal as to the length of time.

In Vedaanga these units of time are of mean average length. Broadly speaking, the moon moves 12^{0} away from the Sun in a tithi, so that in 30 tithis it covers 360^{0} and returns to its original i.e. new-moon position. For a layman a full-moon day is the 15th tithi. The lunar month is further divided in two halves. The first half, during which its phase grows, is called Shukla Paksha i.e. the brightning with full moon on its last tithi. The latter half of month is "Krishna Paksha" i.e. the dark wing. These wings are also called *Shuddha* and *Vadya Pakshas* respecively. The tithis in these pakshas are numbered from 1 to 15 each e.g. bright 1st tithi, dark 8th tithi and so on. For a layman the moon looks semi-circular on the 8th tithi of these pakshas. Thus by practice even an illiterate person can tell the tithi of a day simply by looking at the phase of the moon. In Vedaanga period, the length of the tithi was fixed by dividing the time taken by 12 lunations by 360 which is fairly constant.

NAKSHATRAS

The apparent path by which the planets, the moon and the sun move in the sky on the background of the stars is called a 'Raja Marg' (Royal Path) in the Aitareya braahmana. It is called the Zodiac in Greek astronomy, because they imagined 12 pictures of animals on this path. Thus there are 12 constellations on the Zodiac of equal length i.e. 30^0 each. The central line of this Zodiac is called 'the ecliptic'. The centre of the Sun's disc is supposed to move on the ecliptic in its journey. In the prehistoric period man had no means to mark the path of the Sun on the background of the stars. Hindus ingeniously treated the path of Jupiter as the ecliptic. In the Taittireeya Samhitaa the author addresses the moon as carrier of 'Soma Juice' and tells that Jupiter would guide her. (Tait Sam 1-2-3). It is worthy to note that the path of Jupiter has minimum deviation of 1.305^0 form the ecliptic.

Hindus divided ecliptic path into 27 divisions called *nakshatras*. The distance travelled by the moon in the sky from one place of the full-moon to the next is more than a complete circle. It is about two *nakshatras* in excess. The moon was expected to travel one *nakshatra* in a day. It therefore travelled 29 and 30 *nakshatras* in alternate months. Hindus therefore presumed the existence of an additional or ancillary *nakshatra* called Abhijit. The number of *Nakshatras* were therefore 27 (i.e. 29-2) and 28 (i.e. 30-2).

Hindus numbered the lunar dates according to the phase of the Moon on the respective day. Generally new-moon day was called as the last day of the month. They named the day according to the sidereal position of the Moon. For example in Shaanti Parva of Mahaabhaarata (M.B.) Baliraam is said to have described his journey around the river Sarasvati on his vist to various pilgrims. He says, "Forty two days have passed since I left. I had set-off on Pushya-day (Crab-day) and reached here on Shravana-day. (Altair day). Oh Maadhava I would like to watch the mace-fight of the two of my deciples" (M.B. 9 - 33.5) Lagadha

* List of Nakshatra

1. **Ashvinee** *(group)*
Beet Arietis 'Hamal'
(Jau) जौ

2. **Bharanee**
41 Arietis
(Nya) ण्य

3. **Krittikaa** (group)
Eta Tauri
'Alcyone' (Tri) तृ

4. **Rohinee**
Alpha Tauri
'Aldeberon' (Ro) रो

5. **Mrigasheersha**
Lamda Orionis
(group) (Mri) मृ

6. **Aardraa**
Gama Geminorum
"Alhena" (Draa) द्रा

7. **Punarvasu**
Bita Geminoum
(Polax) (Soo) सू

8. **Pushya** (group)
Delta Cancri
(Shvah) ष्यः

9. **Aashleshaa**
Zita Hydrac
(Shaa) षा

10. **Maghaa** (Regulus)
Alpha Leonis
(Ghaa) घा

11. **Poorvaa Phalgunee**
Thita Leonis
(Gah) गः

12. **Uttaraa Phaalgunee**
Beta Leonis
'Denebola' (Maa) मा

13. **Hasta** (group)
Delta Corvi
(Ha) ह

14. **Chitraa**
Alpha Virginis
'Spica' (Chit) चित्

15. **Swatee**
Alpha Bootis
'Arcutus' (Swaa) स्वा

16. **Vishaakhaa** Alpha
Librae Zubeneigenubi
Libra (Khe) खे

17. **Anuraadhaa**
(group) Bita Scorpii
'Dschubba'
(Dhaa) धा

18. **Jyeshthaa**
Alpha Scorpii
'Antares' (Ry) यें

19. **Moola**
Lamda Scorpii
"Shaula" (Moo) मू

20. **Poorvaashaadha**
Epsilon Sagattarii
Kans (O) Astralis ओ

21. **Uttaraashaadhaa**
Pai Sagattarii
(Shave) श्वे

22. **Shraavana**
Alpha Aquilae
"Altair" (Nah) नः

23. **Shravisthaa** Alpha
Delphini (Group)
(Sthaa) ष्ठा

24. **Shatabhishaj**
Lamda Aquarii
(group) (Shak) षक्

25. **Poorvaa**
Bhaadrapadaa
Alpha Pegasi
'Markab' (Ajah) जः

26. **Uttaraa**
Bhaadrapadaa
Gama Pegasi
"Algenib" (Hi) हि

27. **Revatee**
Zita Pescium
(Re) रे

subsequently fixed the number as 27 for mathematical purposes. The reasons for this change are given at a later stage. The list of *nakshatras* is given p. 18. For identification, English names of important stars in each *nakshatra* are given against their names.

SUPPLEMENTARY :- Abhijit (Alpha Lyrae) is traditionally inserted after the 21st *Nakshatra* Uttaraashadhaa, where there is no space for insertion. There is a gap of one *nakshatra* between the 23rd nakshatra Dhanishtaa and the 24th nakshatra Shatabhishaj.

RVJ. 14 gives a list of symbols for each nakshatra. The symbols are given at end of the names of nakshatras in the aforementioned list.

Ritu-Shesh (ऋतुशेष)

RITU - SHESH (ऋतुशेष). If the length of the month and the year are measured in tithis, the lunar year has a duration of 30 x 12 = 360 tithis, and the solar year consists of approximately 371.05 tithis. The difference is of about 11.05 tithis. It is fairly constant. It is called *ritushesha* in Vedaanga. At the end of every solar year, this ritushesha gets added and ultimately when the total of tithis exceeds 30, they constitute an additional month. Astronomers tell us that in 19 years there are seven such additional lunations. Readers will appreciate the following results of multiplications.

30 × 7 = 210 *tithis*

11 × 19 = 209 *tithis* (i.e. 210 - 1 *tithis*)

Perhaps these results inspired sage Lagadha to frame a yuga of 19 years with one leap year in each yuga. In Lagadha yuga there are 18 years with 371 lunar-days and one year with 372 lunar days.

Astronomical bodies move under astronomical forces and complete their cycles. We cannot therefore get ratios of various speeds of their cycles or revolutions in round figures. A leap or cut mechanism is therefore required to express the ratios of their speeds. Sage Lagadha was required to express the number of months and an year in tithis. Similarly a tithi, a day and lunar nakshatra in *kalaas*. At every place he has used a leap or cut mechanism. Hindus call such tithis as *vriddhi* (वृद्धि) and *kshaya* (क्षय) tithis. Modern students of Vedaanga are aware of this leap mechanism, but missed to find out the places where it was used. For internal divisions of a year of 372 tithis is a suitable figure, because it is divisible by 12, it could be divided in six seasons, but in reality the solar year consisted 371 tithis. Therefore the ritushesha as given in Vedaanga is 11 tithis (371-360) and not 12 tithis. (372-360). If we presume ritushesha as 12 tithis for constructing a yuga, we get a 5-year cycle. If we multiply 12 tithis by 5, we get 12 x 5 = 60 additional tithis, which means we have to add two intercalary months in a 5-year cycle. A yuga of five years in that case would consist of 60 + 2 = 62 months. This is the conclusion from Vedaanga so far drawn by scholars, including Lokamanya Tilak. We will see in this part of the book that Rig Jyotisha is based on yearly ritushesha of 11 tithis and not 12 tithis. S.B. Dixit, Lokmanya Tilak and Prof. Kuppanna Sastri inferred that the Vedaanga is based on a five-year cycle in their commentaries. Some scholars have interpreted the words Uttaraayana and Dakshinaayana as autumnal and vernal equinoxes, while some have treated them as winter and summer solstices. For the convenience of narration, they are presumed as solstices). Yajus recension is definitely based on a 5-year cycle. This part of the book is confined to the explanation of Rik recension. Yajus recension is used only for comparison.

Some guidelines for Interpretation.

Before we begin our work of deciphering the verses of Vedaanga Jyotisha and solving the puzzles therein, we must know (i) the purpose of composing the verses in the text, (ii) what were the minimum requirements of the vedic sages in respect of the time reckoning, about the knowledge of the respective positions of the Sun and the Moon in the sky, for performing yearly, half yearly and monthly sacrifices. (iii) that the Rik-text of Vedaanga Jyotisha is a precise hand-book in this respect. Its author, therefore, presumes that the sages had a knowledge of the elements of Vedic-Calendar e.g. the names of the nakshatras etc. and the meaning of the technical words therein, (Let us use the abbreviations RVJ for Rik-text and YVJ for Yajus-text of Vedaanga Jyotisha.). The aim and object of composing Vedaanga Jyotisha are precisely stated in RVJ. 29 (इत्येतन् मासवर्षाणां). Following are the aims and objects of RVJ, commonly approved by scholars :-

1. a). To separate intercalary months (अधिकमास) whenever they occur before (अयनारंभ)the days of winter and summer solstices (RVJ. 4 and 23).

b). To know the tithi (lunar date) of the days of future (अयनारंभ) winter and summer solstices.

c). To know the names of the days (lunar nakshatra) of successive winter and summer solstices (The nakshatra) covered by the moon is called lunar nakshatra (चांद्रनक्षत्र)

d). To classify and name a year according to the tithi and the lunar nakshatra on the new year's day (वर्षारंभ)i.e. the day of winter solstice.

e). To plot the sidereal positions of the Sun and the Moon on the ecliptic at the end of each lunar fortnight (पर्वन) by sub-dividing the ecliptic, according to me in 3339 parts. (called as bhaamshaas).

f). To know the serial number (in cyclical list) and the name of lunar - nakshatra (lunar day) at succesive lunar syzygies (पर्वात पौर्णिमा - अमावस्या RVJ. 10 and 12.)

g). To know in advance the time of change of a lunar nakshatra in number of Kalaas on the day of syzygy presuming that the day begins at mean time of Sun-rise.

h). To give all other requisite information ancilliary to aforementioned purpose. However the author of RVJ does not narrate unnecessary calendrical details, e.g. number of risings of Shravistha in a yuga etc.

The text RVJ. being religious some verses in it are utilised for religious introduction and religious conclusion, The sanskrit language of these verses is easy. The difficult problem is about explaining the technical verses. While explaining such verses we should keep in mind the intention or the purpose of composing the verses. This is the **first** guide line.

2). An interpreter of a document knows a rule "The author of the document has placed a comma or a full-stop in the document with all his wisdom" It is only in very rare case we whould think that some scribe in the past made some mistake in writing the document. Most of the scholars have so far thought that the text of RVJ. got distorted due to passage of time in conveying it from one generation to the next. They have suggested several emendation and published such emended editions. We think that our first effort should be to interprete the original traditional text as it was in times of Bhatotpala (988 A.D.). This is the **Second** guide line.

3). If a verse or a portion of a verse is found ambiguous i.e. if it gives two or more meanings, we should apply the rule of consistency. The meaning which is consistent with other part of text should be accepted. This is the **third** guide line.

4). In the time of Lagadha only arithmetics from the sciences of mathematics was known to the learned people. They had no knowledge of algebra, spherical geometry, etc. They would observe and record the positions of the Sun and the Moon and could only calculate the mean positions of the Sun and the Moon. Mathematical calculations followed step by step. It is therefore possible that the 5-year luni-solar cycle might have been used as intermediate step for calculations, treating it as of first approximation. The 19-year luni-solar cycle might have been used for the final step. This possibility should not be ignored. This is **fourth** guide line. We have explained in this book Rik-text of Vedaanga on the basis of 19-year lunisolar cycle theory.

5). We would request the reader to keep his mind open. Their conclusion should not be affected by extreneous considerations like (i) what type of cycle is used in Mahabharata or other Vedic or Pauranik texts (ii) if Rik-text of Vedaanga has a base of 19-year cycle why eminent ancient astronomers like Varahmihira, Bhatotpala, Brahamagputa, Bhaskara have not mentioned this in their text? We would say that if they had found the 19-year cycle in Rik-text and explained it, series of Western and Indian scholars might have not treated it as a prehistoric puzzle and laboured so much to solve it. We should therefore start our work with an open mind and strictly rely on general rules of interpetation of documents narrated above. That is the **fifth** guide line.

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CHAPTER - 4

Intercalary months : Separation

अतीतपर्वभागेषु शोधयेद् द्विगुणां तिथिम् ।
तेषु मण्डलभागेषु तिथिनिष्ठां गतो रविः ॥२०॥

तदर्धं दिनभागानां सदा पर्वणि पर्वणि।
ऋतुशेषं तु तद्विद्यात् संख्याय सहपर्वणां ॥ RVJ 23

इत्युपायसमुद्देशो भूयोप्येनं प्रकल्पयेत् ।
ज्ञेयराशिं गताभ्यस्तान्विभजेज्ज्ञानराशिषु ॥२४॥

The Yuga of sage Lagadha consists of 19 solar years, which used to begin on winter solstice on a day that follows the new-moon, the month of Regulas (माघ) began on that day. The yuga was divided in 38 solar-semesters. One of the object of these verses was to foretell the phases of the moon i.e. the lunar date (Tithi) of the first day of every solar semester in a yuga which began either on winter solstice or summer solstice.

It is easier to calculate the lunar date (Tithi) of the first day of every solar-year in a cycle of 19-years. In the European calender a day begins at mid-night. Even if five seconds pass after mid-night at the end of the year we call it as the first day of the new year. That is how we give a serial number to a date of a year. Sage Lagadha began his day at the mean time of Sun-rise (i.e. at six a.m. local time (Please see verse No. 34.) If 'Y' number of solar years had passed, the beginning of the yuga the lunar date at the beginning of the next solar year would be $(11\ y + 1)$ because the length of solar year minus the length of the lunar year is 11 tithis (which is called ritushesh) The lunar date at the beginning of the third year would be $11 \times$ [illegible] $1 = 23$rd tithi.

We have two complete years which give a ritushesh at the rate of 11 tithis for a year and the additional figure one indicates the serial number of the tithi.

The bright wing of lunation is called Shukla-paksha. Let us denote the tithis as SK-1, SK-2 and so on. The dark wing is called Vadya-Paksha. Let us denote the tithis in this wing as Vd 1, Vd 2 and so on. The 23rd tithi in the afore mentioned example would therefore be 23-15 i.e. Vd. 8. The third year in a yuga should therefore begin with Vd. 8th.

Ritushesh and consequently the dates of the beginnings of months increase at the rate of one tithi per solar month. This rule holds good only for internal calculations in a semester. At the end of a year we have to subtract one tithi from the total number of 12 tithis.

When ritushesh increases more than 30 tithis an intercalary month should be separated. For example at the end of three years we have -

3 (12 – 1) = 33 tithis of ritushesh for
obtaining the date of the begining of the
4th year we have to add one tithi and separate the intercalary month -

(33 + 1) – 30 = 4 (i. e. SK, 4th tithi)

Dates At The Beginning of Semesters

In the earlier paragraph of this Chapter we have practically used a method for convertion of solar time units into lunar time units by calculating the difference of ordinal numbers of a tithi and of corrosponding day. The difference is one tithi per month and 11 tithis per year. However the Vedic sages required the lunar dates at the beginning of every semester (अयन). Sage Lagadha therefore changed the base of calculation from 'months' to 'half months' i.e. parvans (fortnights) because there are 12 Solar parvans in a semester. The scale of increase in ritushesh was therefore used as half tithi per parvan.

Ritushesh per semester is 11/2 tithis. Hindus use half tithi as time unit. It is called as "Karana" (करण). It was not in use in Lagadha's period, otherwise the calculations would have been easier.

1 semester = 12 parvans
ritushesh per parvan = 1 karana and
ritushesh per semister = (12 - 1) Karana
= 11 Karanas
Or in other words
1 solar semester = 1 lunar semester + 11 Karanas

The method for calculating ritushesh became little longer because the unit "Karana" was not is use. Sage Lagadha chooses as first step to substract 1 parvan per semester, the balance of 11 parvans are useful for further calculations. Let us call these 11 parvans as *useful parvans*. If the total number of parvans are 'P' and the number of complete semesters are 'H' then,

$$\frac{P}{12} = H + \text{(a fraction)}$$

We have then P - H = *useful parvans* because the number of rejected parvans are H.

Example : Separate *useful parvans* from total number of 148 parvans (74 solar months) and find out the tithi of the last day.

$$\frac{\text{148 Parvans}}{12} \doteq \text{12 semesters} + \text{4 parvans}$$

$\therefore$ Useful parvans = (148 - 12) = 136.

From a group of 60 *useful parvans* we compute a ritushesh [illegible] intercalary month of 30 tithis each.

Therefore after separation of two groups of 60 parvans for two intercalary months, we get -

$$136 - (2 \times 60) = \text{16 parvans}$$

From these balance of 16 parvans we get a ritushesh of ½ tithi for each parvan i.e. 8 tithis.

The lunar date of last day of 148th parvan from the beginning of a Yuga is SK. 8th tithi.

Seventy fifth solar month, (74 + 1), would therefore begin on SK. 9th.

The relevant verses explaining this method are, RVJ 4, RVJ 23, and RVJ. 24.

Definition of "Raashi"

Before we proceed of know the meaning of RVJ 4, we should know the meaning of the word "raashi" in the said verses. Every *useful parvan* gives a ritushesh of ½ tithi. We therefore get a ritushesh of one lunation from a group of 60 *useful* parvans. The first tithi of the month which follows "M" number of inter-calary months commences after (60 M + 2) *useful parvans* from the begining of the yuga.

Sage Lagadha therefore calls (60 M + 2) *useful parvans* as "raashis". The meaning of the Sanskrit word "raashi" is a heap, mass, collection, quantity, multitude (Aptes' Sanskrit - English dictionary). It also means a total forming a unit. We can therefore call aforementioned *useful parvans* as "raashi parvans". (We exclude rejected parvans in raashi at the rate of one per dozen). RVJ. 4 reads as under :-

निरेकं द्वादशार्धाब्दं द्विगुणं गतसंज्ञिकं ।।
षष्ठ्या षष्ठ्या युतं द्वाभ्यां पर्वणां राशीरुच्यते ।।४।।

Nirekam dwaadashaardhaabdam dwigunam gata samjnikam | |
Sashthyaa shasthyaa yutum dvabhyaan parvanam Rashiruchyate | |4| |

The literal translation of the words in RVJ, 4 is as follows :-

Nirekam - subtract one
Dwaadasha - twelve
Ardhaabdam - half year
Dwiguham - double
Gatasamjnikam - presume previous
Shashthyaa - 60
Yutam - together
Dvaabhyam - by two
Parvanaam - of parvans
Raashi - total forming a unit
Uchyate - are called

The text resembles to some extent an albebraic equation where we have to substitute the constants a, b, c by some known quantities to get the value of the unknown quantity 'X'. But we must know, what a, b, c represent. In the aforementioned verse we must know what nirekam or dwadasha mean, whether month, year or a day.

Almost all the scholars comment that the text of RVJ. is defective. According to them the object of this verses is to find out the total number of lunar parvans passed till the end of given number of solar years and solar months. This includes computation of intercalary months till the given time. They suggested two corrections in the first line(i) to substitute the word "Dwaadashaardhaabadam" by the word "Dwaadashaabhyastam" - (multiply by twelve) and (ii) to substitute the word "gatasamjaikam" by the word "gatasamyutam" - (add previous).

No correction is suggested in the second line of the verse RVJ, 4. The amended verse reads as under -

निरेकं द्वादशाभ्यस्तं द्विगुणं गतसंयुतम् ।।
षष्ठ्या षष्ठ्या युतं द्वाभ्यां पर्वणां राशीरुच्यते ।।४।।

S.B. Dixit has also suggested the aforementioned corrections. His translation reads as under -

"Reduce the current year number (out of 5-year-cycle) by one. Multiply the result by 12. Add number of months elapsed. Double the sum. Add 2 for every sixty. The resulting sum is called *parvan* raashi."

Example:- Find out the parva - number at the end of 7th month of the 3rd year.

Solution :- (Current year number) - 1 = 3 - 1 = 2.

(2 x 12 + 7) x 2 + 2 = 64. He has added two parvans because the sum exceeds 60. Therefore 1 intercalary month i.e. 2 parvans are added.

This is how almost all the scholars even after reading commentaries of pandits of Siddhanta-age have explained the verse so far. The unclarified numbers are clarified in the following manner .-

Reduce one	-	Year
Multiply by 12	-	to obtain number of months
Double the result	-	to obtain the number of parvans.

We cannot change the text of RVJ, 4. It appears to us that the text is based on 19-year lunisolar cycle. We have given above the meaning of the words in unamended text. We shall now arrange them to make a proper meaning.

अन्वय :- निरेकं द्वादश (पर्वाणि) (प्रति) अर्ध अब्दं ।
द्विगुणं (पर्व) गत संज्ञिकं ।
द्वाभ्यां युतं षष्ठ्या षष्ठ्या
पर्वणां राशिरुच्यते ।।

Prose order :- Subtract one (parvan) from twelve (solar parvans) in (each) semester. Assume two parvans (as balance from) previous (yuga). Groups of sixty parvans inclusive of (aforementioned) two parvans are called raashis.

In such a reading of the verse, we substitute the unknown quantity everywhere in number of parvans, the name of which is specifically mentioned in the second line of the verse. The verse gives only an inncomplete previous stage for calculating the ritushesh. It gives only the number of raashi-parvans. The next step is to divide the number of raashi-parvans by two so that the raashis get converted into intercalary months and the balance of parvans get converted into ritushesh indicating the date of the beginning of the text solar parvan.

The auxiliary two parvans assumed as balance from previous Yuga are meant for giving an ordinal number to the tithis of the first day of relevant parvan or relevant semester. They are mentioned in the first line of RVJ 4, as "dwigunam gata-samjinikam". Raashis are therefore equal to (60), (120), (180), (240), (300), (360) and (420) Raashi-parvans.

The rule for obtaining ritushesh by dividing the number of raashi-parvans by two is given RVJ 23.

तदर्धं दिनभागानां सदा पर्वणि पर्वणि ।
ऋतुशेषं तु तद्विद्यात् संख्याय सहपर्वणाम् ।।२३।।

All scholars agree that the word (दिनभाग) "dinabhagh" means tithi bhaaga i.e. portion of a tithi. English translation of RVJ 23 is as follows-

"For each of those (Raashi) parvans (as obtained from RVJ. 4) we have half portion of a tithi. Know that its sum is a ritushesh a long with the given number of parvans". The verse RVJ, 23 begins the word "तदर्ध" (half of them) indicating that it is a subsequent step in mathematical operation while similar verse in Yajus-text (YVJ. 41) begins with the words "यदर्ध" indicating that a relates to a single or first step of mathematical operation. In counting ritushesh according to Yajus text raashi-parvans are not separated from the total number of parvans (for a given time of calculations.)

Tithis to be counted on the days of solstice.

The practice to make calculations for separating intercalary months and balance of ritushesh at the end of semisters is apparent from (i) the first line of RVJ 4, (ii) first line of RVJ 8, (iii) second line of RVJ 19. and (iv) RVJ 24. Calculations were made on the days of winter solstice or summer solstice. Raashi-parvans were grouped in raashis and balance of parvans were treated as fraction of raashis. This is mentioned in RVJ, 20 and 24.

अतीत पर्वभागेषु शोधयेत् द्विगुणा तिथिम् ।।
तेषु मंडल भागेषु तिथिनिष्ठां गतो रविः ।।२०।। RVJ, 20

Apte's Sanskrit-English dictonary gives the meaning of the word "Nisthaa" (निष्ठा) as foundations, fixity, steadiness. Hence the words 'tithi-nisthaa' imply "When the Sun reaches a day of solstice". Verse 20 therefore means "make correction at extending parvan-portion to avoid the error of doubling of tithis at the point of circle where the sun becomes steady (On the day of solstice)". This refers to the reduction of half tithi of ritushesh per semester from the total ritushesh of 6 tithis, as given in RVJ 4. It specifically mentions the days on which calculations of ritushesh be made for finding out the observations of the place of the moon. The next procedure is given in verse number 24.

इत्युपाय समुद्देशो भुयोऽप्येनं प्रकल्पयेत ।
ज्ञेयराशौ गताभ्यस्तान् विभजेज्ज्ञान राशिषु ।।२४।। RVJ. 24

The grammar of the verse is little obscure but the meaning is clear-

"With these aims and means, by process of repeatitions separate the fractions of raashi from the known number of complete raashis".RVJ. 24

Raashi-parvans which could not be grouped in the units of 60 parvans, and left as balance of useful parvans are in this verse called 'Raashi Vibhaag". If we divide the number by 2 (as per RVJ-23) we get the tithi of the next semister. (Please see table 1 Column no. 4 and 7). It gives us the balance number of parvans at the beginning of 38 semesters in yuga.

The quantities of balance of parvans given in column No. 4 and 7 of table No. 1 are used for calculating the changed tithis at winter solstice and summer solstice as given Table No. 2

The word "raashi" appears only at two places in Rik-text i.e. in RVJ 4 where it is defined and in RVJ 24 where it is used. All scholars have so far given two different meanings to this word. They have explained RVJ 24 as a general "rule of three" in arithmatic.

The reason for giving the definition of the word "raashi" at the earlier part of the text RVJ. 4 and its actual use in the latter part of the text of

Table No. 1

Sr. No. 1	First Ayanam 2	Summer Solstice 3	Balance Parvans 4	Second Ayanam 5	Winter Solstice 6	Balance Parvans 7
0	(0× 11+2)		2			2
1	(1× 11+2)	= 11+2= 13	13	(2× 11+2)	= 22+2= 24	24
2	(3× 11+2)	= 33+2= 35	35	(4× 11+2)	= 44+2= 46	46
3	(5× 11+2)	= 55+2= 57	57	(6× 11+2)	= 66+2= **68**	8
4	(7× 11+2)	= 77+2= 79	19	(8× 11+2)	= 88+2= 90	30
5	(9× 11+2)	= 99+2=101	41	(10× 11+2)	=110+2=112	52
6	(11× 11+2)	=121+2=123	3	(12× 11+2)	=132+2=134	14
7	(13× 11+2)	=143+2=145	25	(14× 11+2)	=154+2=156	36
8	(15× 11+2)	=165+2=167	47	(16× 11+2)	=176+2=178	58
9	(17× 11+2)	=187+2=**189**	9	(18× 11+2)	=198+2=200	20
10	(19× 11+2)	=209+2=211	31	(20× 11+2)	=220+2=222	42
11	(21× 11+2)	=231+2=233	53	(22× 11+2)	=242+2=**244**	4
12	(23× 11+2)	=253+2=255	15	(24× 11+2)	=264+2=266	26
13	(25× 11+2)	=275+2=277	37	(26× 11+2)	=286+2=288	48
14	(27× 11+2)	=297+2=299	59	(28× 11+2)	=308+2=**310**	10
15	(29× 11+2)	=319+2=321	21	(30× 11+2)	=330+2=332	32
16	(31× 11+2)	=341+2=343	43	(32× 11+2)	=352+2=354	54
17	(33× 11+2)	=363+2=**365**	5	(34× 11+2)	=374+2=376	16
18	(35× 11+2)	=385+2=387	27	(36× 11+2)	=396+2=398	38
19	(37× 11+2)	=407+2=409	49	(38× 11+2)	=418+2=**420**	

RVJ. 24 is that the definitions are usually given in the beginning of the text

The last year in the 19-year-cycle is a leap year. It consists of 372 tithis. We do not require to deduct ½ tithis from the semesters of this year. The first line of RVJ 4 is, therefore, not applicable to this year.

Note of Comparison

YVJ. 42 is a similar verse in Yajus-text as a substitute for RVJ. 24. Dr. Sham Sastri, Prof. Kuppanna Shastri and Dr. H.M.Yagnik prefer its wordings to that of RVJ 24. YVJ 42 reads as under :-

इत्युपाय समुद्देशो (भूयो ऽ प्येह्नः) प्रकल्पयेत् ।।
ज्ञेय राशीं गताभ्यस्तां विभजेत् ज्ञान (राशिना) ।।२४।।

In the first line the word "अप्येनं" is substituted by the word अप्येह्नः and in the second line the word राशिषु is substituted by the word राशिना. Prof. Kuppanna Sastri gives the translation in following words.

"The known result is to be multiplied by the quantity for which the result is wanted and divided by the quantity for which the known result is given (in other words follow rule of three)."

The word "अह्नः" which is suggested to be substituted in the first line means a "day" and in the second line the case of the word "raashi" is changed from *locative* राशिषु to *instrumental* राशिना to express that the division is to be made by a ratio.

It is highly improbable that a special text of "Vedaanga" in the form of hand-book would provide a simple rule of three. The word "raashi" is defined in RVJ. 4. It ends with the words "it is called raashi "राशिरुच्यते". The only verse in which the word "raashi" is used RVJ. 24. It cannot therefore be explained as simple rule of three.

Change of civil year - its nomenclature.

We have seen that tithi changes according to mean synodical posistion of the moon with respect to the sun. Its phase at an angular distance of 12^0 from the sun is a unit of tithi. Changing of a tithi is therefore not a local time but a universal time. The length of "normal year" consists of 365 days & 5-hours (see p. 50). It therefore does not change at a fixed local time or a standard time of a state. It may change at any hour of a day. According to Hindu calendar the civil day changes at mean time of sun-rise. The civil solar-year is therefore expected to change at the time of sun-rise (See RVJ 34). We are therefore required to reduce 1 tithi from the new-year tithi of a normal year to get the civil tithi of the winter-solstice. Such tithis are shown in column 3 of table 2. They are required for classification of years as explained in the next chapter. However the first day of the yuga has to begin at zero time on shukla pratipada.

θ θ θ θ θ

CHAPTER - 5

Classes of Years
(according to tithis)

द्विगुणं सप्तमं चाहुरयनाद्यं त्रयोदश ।
चतुर्थं दशमं चैव द्वियुग्माद्यं बहुलेप्यृतौ ।। RVJ 8

During the Vedaanga age, lunar years were classified into five types (i) Samvatsara (ii) Anuvatsara (iii) Parivatsara (iv) Idvatsara and (v) Idaavatsara.

These names have connotations somewhat similar to those used for motor car engines. They therefore be called (i) tuned year (ii) advanced year (iii) converse year (iv) extra-retarded year (v) retarded year.

We have seen that ritushesha in 5-year yuga system would come to 12 tithis per year, and 6 tithis per ayana. The year used to begin in the month of Maagha which was named after the asterism Regulus (Maghaa) in the constellation Leo. During the Vedaanga age summer solstice used to occur in the month of Shraavana (the month in which full moon appeared near Delphinus). If we begin with the lunar year and the yuga on the first day of the month 'Maagha' with winter solstice on the said date, the lunar year is expected to lag behind by 12 tithis after a year and a lunar semestar would lag behind by 6 tithis. As a result, in the second semester of the year we would get the Vedic date as 7th on the summer solstice, 13th on the next winter solstice, and so on. In Yajus Jyotisha, this verse corresponds to RVJ 8. it is as under :-

प्रथमं सप्तमं चाहुरयनाद्यं त्रयोदश ।
चतुर्थं दशमं चैव द्वियुग्माद्यं बहुलेप्यृतौ ।। RVJ 9

Most of the scholars have treated this recension to be correct and the Rik recension as deformed. S.B. Dixit is one of them. From contemporary literature we get five names of years. Mr. Dixit has treated the figures in this verse as tithis on winter and summer solstice, and classified the years according to such tithis (Please see chart I).

Chart - I

Sr. No.	Name of the year	Winter Solstice	Summer Solstice
1.	Samvatsara	Maagha Shu. 1	Shraavana Shu. 7
2.	Parivatsara	Maagha Shu. 13	Shraavana Vad. 4
3.	Idaavatsara	Maagha Vad. 10	Shraavana Shu. 1
4.	Anuvatsara	Maagha Shu. 7	Shraavana Shu. 13
5.	Idvatsara	Maagha Vad. 4	Shraavana Vad. 10

When the Vedic date of a month exceeds 15, it is counted as Vadya 1st for 16th, Vadya 2nd for 17th, and so on. S. B. Dixit prepared this table from Somaakaavs' comentary on Yaajus-Jyotisham.

The ratio of speeds of revolution of the Sun and the Moon cannot be very simple or integral, so that these five types of years would begin at particular fixed dates. The scheme of Rik-text of Vedaanga is to use 5-year luni-solar cycle, to classify and name the classes of the years. Let us therefore interpret these dates as the limits of dates for the beginnings of luni-solar year. They should be as follows :-

Chart - 2

Sr. No.	Name of the Year	Date of a day before Winter solstice
1.	Samvastsara	1st Shuddha Maagha to 6th Shuddha Magha.
2.	Anuvatsara	7th Shuddha Maagha to 12th Shuddha Magha.
3.	Parivatsara	13th Shuddha Maagha to 3rd Shuddha Magha.
4.	Idvatsara	4th Vadya Maagha to 9th Vadya Magha.
5.	Idaavatsara	10th Vadya Maagha to Amaavaasyaa.

The dates of the beginning of a luni-solar year should be taken from table No. 1 column 7. This column gives balance of parvans according to RVJ. 24. The number should be divided by two according to RVJ. 23 to obtain the tithi. The RVJ. verse 8 begins with the word dvigunam i.e. doublet' instead of the word prathaman (first). This indicates that the numbers given in the verse are ordinarily tithis, but they are obtained from double the balance of parvans. The following figure will express in a better

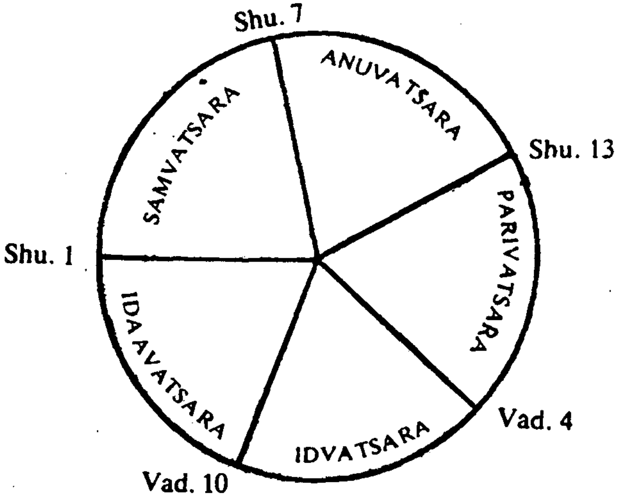

FIGURE -1

way the limits which are already given in table No. 2.

The words *bahule'pritau* occurring at the end of the 8th verse support our interpretation. They indicate that the dates given in the said verse are only to show the lower limits of five zones. In different years, there exists some additional ritushesha.

If we divide the number given in column 7 of table No. 1 by 2, we get the tithis of the beginnings of the next normal year on the day of winter-solstice. Table No. 2 is prepared by reading table No. 1 and figure No. 1 together. Column 4 of table 2 gives us the first tithi of the normal year. Column 3 of this table gives the tithi at the time of Sun-rise on the day of winter solstice from which we get the name of the class of the year. It is given in column 2 of the table.

The Shalahas

The aforementioned rule of classification of years can be called a "Shalaha rule". The Vedic sages observed a week of six days called "Shalaha" (i.e. hexad.) A lunar month was also used to be divided in five tithi-shalahas. The solar year was named according to the serial numbers of Shalaha in the lunar month of Magha, (Regulus) in which the sunrise on the day of winter- solstice occured. It was solar-new-year day. Thus if

Table No. 2

Sr. No.	**Name of the year**	**New Year day at Sunrise**	**Winter Solstice**	**Mid year**	**Summer Solstice**	**Year end**
1	2	3	4	5	6	7
1.	**Samvatsara**	Shu. 1	Shu. 1		Shu. 7	
2.	Anuvatsara	Shu. 11	Shu. 12		Vad. 3	
3.	Idvatsara	Vad. 7	Vad. 8		Vad. 14	+m
4.	**Samvatsara**	Shu. 3	Shu. 4		Shu. 10	
5.	Parivatsara	Shu. 14	Paurn̲imaa		Vad. 6	
6.	Idaavatsara	Vad. 10	Vad. 11	+m	Shu. 2	
7.	**Samvatsara**	Shu. 6	Shu. 7		Shu. 13	
8.	Parivatsara	Vad. 2	Vad. 3		Vad. 9	
9.	Idaavatsara	Vad. 13	Vad. 14	+m	Shu. 5	
10.	Anuvatsara	Shu. 9	Shu. 10		Vad. 1	
11.	Idvatsara	Vad. 5	Vad. 6		Vad. 12	+m
12.	**Samvatsara**	Shu. 1	Shu. 2		Shu. 8	
13.	Idaavatsara	Shu. 12	Shu. 13		Vad. 4	
14.	Idvatsara	Vad. 8	Vad. 9		Amaavasyaa	+m
15.	**Samvatsara**	Shu. 4	Shu. 5		Shu. 11	
16.	Parivatsara	Paurni.	Vad. 1		Vad. 7	
17.	Idaavatsara	Vad. 11	Vad. 12	+m	Shu. 3	
18.	Anuvatsara	Shu. 7	Shu. 8		Shu. 14	
19.	Idvatsara	Vad. 3	Vad. 4		Vad. 10	+m
20.	New Yuga begins		Amaavasyaa			

+m Shows Adhikamaasa

the winter solstice day started in the first shalaha, the year was called Samvatsara and if it started in the second shalaha, it was called Anuvatsara and so on. This is an easier way of interpreting RVJ. 8.

Dr. K.D. Abhyankar of Usmania University (Hyderabad) has pointed out two rules followed by Sage Lagadha in giving names to the years (i) Intercalary months occur only in Idvatsara and Idaavatsara (ii) If it is Idvatsara, it comes at the end of the solar year, and if it is Idaavatsara it comes before the summer solstice i.e. in the middle of the year. He drew this inference after reading marathi edition of this book. The rule is correct and useful.

Verification

For verifying with observed dates and tithis our theoretical conclusion accords with actual tithis of Winter-solstices we have chosen a period from 21st of Dec. 1957 to 21st of Dec. 1994 and prepared a Table (No. 3). It supports our interpretation.

Table No. 3

Yuga Year Sr.No.	Date-Winter Solstice	Tithi	Yuga Year Sr. No.	Date-Winter Solstice	Tithi
1.	21 Dec. 1957	Mrg. Vd. 30	1.	21 Dec. 1976	Mrg. Vd. 30
2.	22 Dec. 1958	Mrg. Sh. 12	2.	21 Dec. 1977	Mrg. Sh. 12
3.	22 Dec. 1959	Mrg. Vd. 7	3.	22 Dec. 1978	Mrg. Vd. 7
4.	21 Dec. 1960	Pus. Sh. 4	4.	22 Dec. 1979	Pus. Sh. 4
5.	21 Dec. 1961	Mrg. Sh. 15	5.	21 Dec. 1980	Mrg. Sh. 15
6.	22 Dec. 1962	Mrg. Vd. 11	6.	21 Dec. 1981	Mrg. Vd. 11
7.	22 Dec. 1963	Pus. Sh. 6	7.	22 Dec. 1982	Mrg. Sh. 7
8.	21 Dec. 1964	Mrg. Vd. 3	8.	22 Dec. 1983	Mrg. Vd. 3
9.	21 Dec. 1965	Mrg. Vd. 14	9.	21 Dec. 1984	Mrg. Vd. 14
10.	22 Dec. 1966	Mrg. Sh. 10	10.	21 Dec. 1985	Mrg. Sh. 10
11.	22 Dec. 1967	Mrg. Vd. 6	11.	22 Dec. 1986	Mrg. Vd. 6
12.	21 Dec. 1968	Pus. Sh. 2	12.	22 Dec. 1987	Pus. Sh. 2
13.	21 Dec. 1969	Mrg. Sh. 13	13.	21 Dec. 1988	Mrg. Sh. 14
14.	22 Dec. 1970	Mrg. Vd. 9	14.	21 Dec. 1989	Mrg. Vd. 9
15.	22 Dec. 1971	Pus. Sh. 5	15.	22 Dec. 1990	Pus. Sh. 5
16.	21 Dec. 1972	Mrg. Vd. 1	16.	22 Dec. 1991	Mrg. Vd. 1
17.	21 Dec. 1973	Mrg. Vd. 12	17.	21 Dec. 1992	Mrg. Vd. 12
18.	22 Dec. 1974	Mrg. Sh. 8	18.	21 Dec. 1993	Mrg. Sh. 8
19.	22 Dec. 1975	Mrg. Vd. 4	19.	22 Dec. 1994	Mrg. Vd. 4

NOTE : (1) If we call European leap year as the first year in a group of four years, we have winter solstice on 21st of Dec. in the first and second years, and it is on the 22nd Dec., in the third and fourth year.

(2) In 1982-83 'Paush' (पौष) was an omitted month (क्षयमास).

θθθθθ

CHAPTER - 6

Nakshatra & Yuga

Before Lagadha, people presumed 28 nakshatras, they counted 27 and 28 nakshatras in alternate months. The ancillary nakshatra *abhijit* was dropped for mathematical calculations, and 27 names were retained. As nakshatras were 27 small constellations on the ecliptic, they were used for denoting positions of the planets in the sky. A tithi gives a *phase* of the moon while a nakshatra gives the location of the moon in the sky or the celestial sphere. A lunar month begins at various different places in the sky. Hence we cannot assign a particular nakshatras for a particular tithi. The names of nakshatras were used for naming a day according to the position of the moon, we shall now see how nakshatras were arranged in a 19-year yuga. While making room for nakshatras in a yuga, sage Lagadha took advantage of the following products -

$$19 \times 10 = 190$$
$$27 \times 7 = 189 \text{ i.e. } (190 - 1)$$

Where the number 7 indicates 7 intercalary months in a yuga.

We have seen that there is ritushesha of 11 tithis per year. It is 10 when counted in terms of nakshatras. A separate arrangement for the nakshatras was therefore necessary. We have seven intercalary sidereal months in 19 years. One surplus nakshatra, as above, is required in 19 lunar years for equating them with 19 solar year. If we presume the 19th year as leap year, the total becomes 190 nakshatras. We have thus a ritushesha of 10 nakshatras per year in 19-years cycle. For every ayana or semester it is five nakshatras. For easy computation Lagadha made a list of nakshatras at intervals of five serial numbers.

Lagadha used symbols for the nakshatras with letters either from the names of the nakshatras or the deities presiding over the nakshatras. The list of Nakshtras with symbols in serial order is given on page 18. RVJ. 14 gives a rearranged list of symbols.

जौद्राघः खेऽश्वेहीरोषाचिन्मूषण्यः सोमाधानः।
रेमृघ्राऽश्वाओजस्तृष्वोहर्येष्टा इत्यृक्षालिग्डैः।। RVJ. 14

Lokmanya Tilak called this list as Javaadi list. i.e. a list beginning with Jau. Let us use the same name. The nakshtras in this verse are in the following order.

Sr. No.	Symbol	Name	Serial No from Shravishthaa
1.	Jau	Aashvayujah (Ashvini)	Sr. No. 6
2.	Draa	Aardraa	Sr. No. 11
3.	Gha	Bhagah (Poorvaaphaalgunee)	Sr. No. 16
4.	Khe	Vishakhaa	Sr. No. 21
5.	Shve	Vishve (Uttaraashaadhaa)	Sr. No. 26
6.	Hee	Ahirbudhnyah (Uttaraabhaadrapadaa).	Sr. No. 4
7.	Ro	Rohinee	Sr. No. 9
8.	Shaa	Aashleshaa	Sr. No. 14
9.	Chit	Chitraa	Sr. No. 19
10.	Moo	Moola	Sr. No. 24
11.	Sha	Shatabhishaj	Sr. No. 29 and so on

Mr. S.B. Dixit was the first to decipher the symbols and give the aforementioned list. He tried to give reasons for giving the list of nakshatras in such a peculiar order.

Mr. Dixit tried to give a ratio between the lengths of parvans and solar nakshatras. He presumed that the Vedic yuga consisted of five years. The total number of nakshatras in a yuga would therefore be 27 × 5 = 135. The total number of parvans in a yuga would be 62 x 2 = 124. It was therefore convenient to divide a yuga in 135 x 124 = 16740 subdivisions. He called them Bha-amshas (भ-अंश) Let us denote this unit of angle by 1 Bh^{o}. Thus a parvan consisted 135 Bh^{o}. Mr. Dixit, thereafter, prepared a table showing the positions of the Sun in Solar nakshatras at the end of various parvans. (please see Affendix 3A, B, C, D, E). He pointed out that the difference between Bha-amshas in parvans and those in nakshatras increased by multiples of 11. From these multiples of 11 he subtracted multiples of 27 and showed that the figures 1, 2, 3, 4 appear again at every fifth nakshatra as arranged in Javaadi list RVJ 14.

He further states that he is unable to give the purpose for such an arrangement.

According to us, the purpose for giving Javaadi list in Rik Jyotisha is altogether different' yet simple. I have demonstrated in the beginning of this chapter that ritushesha per ayana is five nakshatras. We need one additional nakshatra in 19 years to make the total 190 nakshatras. The

TABLE No. 4

Shravishthaa = Shravana + 38 divisions of 1/38 nakshatras

Sr.No. of the year.	Winter Solstice	As per RVJ 14	5th Nakshatra	Summer Solstice
1	2	3	4	5
1.	Shravishthaa (shrvana + 38 div.)	ष्ठा रे	Revatee (+13 Nakshatras)	=Hasta
2.	Mriga + 36 div.	मृ घ्रा	Maghaa + 13N	=Shravishthaa
3.	Swaati + ३५ div.	श्वा ओ	Foor. Aash -”-	=Aardraa
4.	Poor. Bhaad + 32 div.	ज स्तृ	Krit + 13N	=Vishaakhaa
5.	Pushya + 30 div.	ष्यं ह	Hasta + 13N	=Utt. Bhaadra
6.	Jyeshthaa + 28 div.	यें ष्ठा	Shravishtha -”-	=Aashleshaa
7.	Ashvini + 26 div.	जौ द्रा	Aardraa -”-	=Moola
8.	Poor. Phal + 24 div.	घः खे	Vishaakhaa -”-	=Bharanee
9.	Utt. Aashd + 22 div.	श्वे ही	Utt. Bhaadra -”-	=Utt. Bhaadra.
10.	Rohinee + 20 div.	रो षा	Aashleshaa -”-	=Shravana
11.	Chitraa + 18 div.	चित् मू	Moola + 13N	=Mriga
12.	Shata + 16 div.	श ण्यः	Bharanee -”-	=Swaatee
13.	Punarvasu + 14 div.	सो मा	Utta. Phal -”-	=Poor.Bhaadra
14.	Anuraadhaa + 12 div.	धा नः	Shravana -”-	=Pushya
15.	Revatee + 10 div.	रे मृ	Mriga + 13N	=Jyeshthaa
16.	Maghaa + 8 div.	घ्रा श्वा	Svaatee + 13N	=Ashvinee
17.	Poor. Aashd + 6 div.	ओ ज	Poor.Bhaadr. -”-	=Poor. Phaal
18.	Krit + 4 div.	स्तृ ष्यं	Pushya + 13N	=Utt. Aash.
19.	Hasta + 2 div.	ह यें	Jyeshthaa -”-	=Rohinee
20.	Shravishthaa	ष्ठा	NewYugaBegins	

first nakshatra i.e. Shravishthaa was therefore, sub-divided in 19 × 2 = 38 divisions. Shravishthaa = Shravana nakshatras + 38 divisions. Table 4 gives ritushesha in nakshatras in each of the 19 years at every solstice.

The second column of Table 4 gives the position of the moon at winter solstice in various nakshatras in a chain of 19 years. In every ayana the ritushesha increases by 4 + 37/38 nakshatra i.e. 5-1/38 nakshatra apparently indicating an increase of 5 nakshatras (in an integral part of the number). If we multiply 4 + 37/38 by 1, 2, 3, 4 etc. we get 4 + 37/38, 9 + 36/38, 14 + 35/38, 19 + 34/38 and so on. Thus the serial number of a nakshatra increases by 5 at every solstice, which is shown in the 3rd column. During one ayana the sun advances through 180°, when it is at summer solstice. The moon therefore advances through 13 + 1/2 nakshatras more, and its position is shown in column 5. Its sidereal position thus shows a retreat of two divisions i.e. 2/38 nakshatra every year, and it receeds by one nakshatra in 19 years. We are therefore required to presume Shravishthaa as a leap nakshatra. This fact is given in verse RVJ 19.

श्रविष्ठाभयां गुणाभ्यस्तान् प्राग्विलग्नान्विनिर्दिशेत् ।
सूर्यान्मासान् षळभ्यस्तान्विद्याच्चांद्रमसानृतून् ।। RVJ 19

Dixit has left the first line of the verse unexplained. Scholars have given different purposes for incorporating this verse in Vedaanga, and have interpreted the words guna (गुण) and lagna(लग्न) in various ways. From Tilak's book it appears that Dvivedi has suggested to change guna (गुण) into gana (गण) and subsequently into bhagana (भगण) i.e. nakshatra to indicate the number 27, and Lala Chhotelal has suggested to treat the meaning of the word lagna (लग्न) as number eight, with the intention to connect Shravishthaa with Krittikaa which are eight units (of nakshatras) away from them. According to him, vernal equinox was then at Krittikas. Lok. Tilak interprets the word lagna as multiples of three counted from Shravishthaa and says that this meaning is conjectural.

According to us, the word गुणाभ्यस्त means repetition, reproduction, i.e. multiples of a number from a multiplication table. Javaadi list gives multiples of five in the number of nakshatras. The word गुणाभ्यस्त in verse

19 is therefore meant to reproduce verse 14 i.e. Javaadi list. The word *vilagna* suggests separation or cutting off. Hence प्राग्विलग्न means separation at the rear side. Sage Lagadha asks us to break the chain of nakshatras at 'Shravishthaa (श्रविष्ठाभ्यां) and go back one nakshatra to create a leap year of nakshatras. In the second line of verse 19 he tells us the results of such an action. He says, "At each end of a group of six solar months, (we) observe ritushesha of lunar nakshatras. We thus explain the verse in the following words :-

"If we break the (chain of) nakshatras, (a nakshatra) before Shravishthaa and repeat (Javaadi) multiplications, we observe a ritushesha in lunar nakshatras at the intervals of six solar months."

In the second line of RVJ 19 we have the words *Sooryaan maasaan shalaabhyastaan* meaning 'at the end of six solar months'. These words did not give any intelligible meaning suited to the theory of a 5-year yuga; Dvjvedi therefore amended them and substituted स्वार्क्षान् for सूर्यान् (see Tilak pp 101) 'sidereal months'. Tilak approved the meaning and amendment. Prof. Kuppanna Sastri substituted स्तर्यान् (Star's) for सूर्यान् which also mean sidereal months. These amendments are not necessary, if we interpret the verse in the context of a 19-year yuga.

The second line of RVJ. 19 is translated by Dixit, Tilak, Dr. Sham Sastri, Prof Kuppana Sastri and Dr. H.M. Yajnik as "There are six lunar seasons in one month of stars (sidereal month)". It ultimately means that there are 402 lunar seasons in a cycle of 5 years. The translation is obviously most unnatural, artificial and without any nexus with the purpose of composing Vedaanga Jyotisha. We will discuss the utility RVJ. 14 as narrated by Prof. Kuppana Sastri and Lok. Tilak at a later stage when we shall complete the explanation of RVJ. 10.

Classification of Years (according to nakshatras)

वसुस्त्वष्टाभगोजश्चमित्रः सर्पाश्विनौजलं।
धाताकश्चायनाद्याश्चार्धपंचनभस्त्वृतुः।। RVJ. 9

Dixit has explained the verse in the following words : "Those nakshatras whose lords are *Vasu, Tvashtaa, Bhaga, Aja, Mitra, Sarpa,* *Ashvini, Jalam, Dhaataa* and *Brahmaa* i.e. *Dhanishthaa, Chitraa, Aardraa, Poorvaa Bhaadrapadaa, Anuraadhaa, Aasleshaa, Aashvayujaa, Poorvashaadhaa, Uttaraa Phaalgunee* and *Rohinee* were at the beginning of the ayanas. There are 4 ½ nakshatras in a season.

Taking into consideration the fact that there are six seasons in India, Dixit explained the last portion of the verse thus : "There are four and a half (27/6) nakshatras in a season". But the words in the verse are quite different : अर्धपञ्चनभस्त्वृतुः which literally mean "half-five sky ritus." The total number of presiding deities in the first part of the verse are also 10. It is clear that five zones of ritushesha of nakshatras similar to those of tithis are assumed in the verse and sage Lagadha speaks of points dividing these zones in two halves, as limits of Ritushesh.

Prof. Kuppana Sastri follows Dixit in explaining the last words in RVJ. 9. However he notes the difficulty in Sanskrit grammer while translating the words "अर्धपंच नभस्तृतुः" (half-five sky ritus). He therefore, amends them as "अर्धपंचमभस्तृतुः" meaning thereby "half of fifth ($4\frac{1}{2}$) vioating the rule of interpretation. Figure 2 will clarity the meaning.

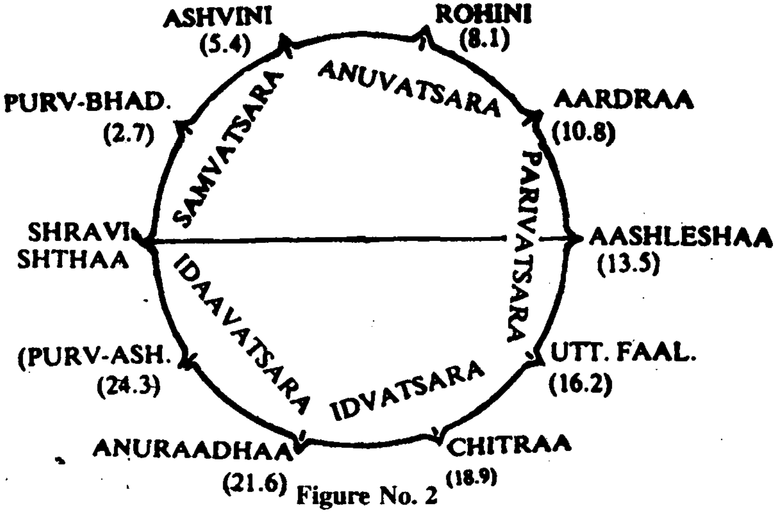

Figure No. 2

It is worthwhile to compare this figure with figure 1. In figure- 1 we have five zones for classification of the years as *Samvatsara*, etc. The criterion of classification is tithis, pratipadaa प्रतिपदा to saptamee सप्तमी etc. In figure-2 we have to divide 27 nakshatra in 5 equal zones. Each zone is of 5.4 nakshatras and one half zone is of 2.7 nakshatras. The names of the nakshatras at the junction of these half-zones are therefore given according to the serial number forming an integral portion of the sub-division 2, 5, 8 etc. The five zones are ritushesha zones. भ or नभस् in Jyotisha means a nakshatra. The poet therefore uses the words अर्धपञ्चनभस्त्वृतुः We can identify the class of year (i.e. Samvatsara etc.) from the nakshatra position of the moon at winter solstice at the beginning of a year. We get it from table 5, which is prepared by a combined reading of table 4 and figure 2. The entry Mriga + 36 divisions in Table 4 at Serial No. 2 is shown as current nakshatra Aardraa in Table 5. All other nakshatras are shown in a similar manner. The last quarter of RVJ. 9 therefore means : "These are the limits of the half divisions of the five zones allotted to ritushesha expressed in nakshatras."

We should also keep in our mind that whenever we classify a year according to the tithi or nakshatra of a day of winter solstice the relevant time to be considered is the time of Sunrise. The list of Nakshatras given in Column 2 of table 4 are therefore relevant for this purpose.

Now we can explain the first line of the Verse 15

जावाद्यंशैः समंविद्यात्पूर्वार्धे पार्वसूत्तरे।

"Know that Javaadi list has a balanced application : First (symbol) for the first half (of the year) and latter (symbol) for the latter half (of the year)." Thus if at winter solstice we have Jau then at summer solstic we have Aardraa (Dra) and so on. (please see table 4).

Table No. 5

Sr.No. of the Year		Winter Solstice	Summer Solstice
1.	**Samvatsara**	Shravishthaa	Chitraa
2.	Anuvatsara	Aardraa	Poor. Bhaa.
3.	Idvatsara	Vishaakhaa	Punarvasu
4.	**Samvatsara**	Utt. Bhaa	Anuraadhaa
5.	Parivatsara	Aashleshaa	Revatee
6.	Idaavatsara	Moola	Maghaa
7.	**Samvatsara**	Bharanee	Poor. Aashd.
8.	Parivatsara	Utt. Phaalgunee	Krittikaa
9.	Iddaavatsara	Shravana	Hasta
10.	Anuvatsara	Mriga	Shravishthaa
11.	Idvatsara	Swaatee	Aardraa
12.	**Samvatsara**	Poor. Bhaa.	Vishaakhaa
13.	Parivatsara	Pushya	Utt. Bhaa.
14.	Idvatsara	Jyeshthaa	Aashleshaa
15.	**Samvatsara**	Ashvinee	Moola
16.	Parivatsara	Poor. Phalgunee	Bharanee
17.	Idaavatsara	Utt. Aash.	Utt.
18	Anuvatsara	Rohinee	Phaalgunee
19.	Idavatsara	Chitraa	Shravana
20.	New Yuga Begins	Shravishthaa	Mriga

It was reasonably impossible to explain verse 19 (श्रविष्ठाभ्यां गुणाभ्यस्तान्) on the basis of five-year astronomical cycle without making drastic changes in the original text. Prof. Kuppana Sastri follows Sudhakar Dwivedi in amending the first line of the verse RVJ. 19. He changes गुण (guna) into गण (gana) and asks us to read the word as भगण (bhagana) keeping भ (bha) silent. The word भगण (bhagana) is then taken to mean as "27 nakshatras" Prof. Kuppana Sastri then explains that because there are 1830 days in five years cycle, we have 1830 + 5 sidereal days in the same period. The total lagnas (ascendent nakshatras) in this period are therefore 1835 x 27 = 49, 545. (Kuppana Sastri p.43)

Plane meaning of the word गुण (guna) is multiples. अभ्यस्त (Abhyasta) means repetition. Lok. Tilak read the amendments suggested by S. Dvivedi in the first line of RVJ. 19 and disapproved them on the ground that "the meaning proposed does not naturally follow from the verse" (page 103). If RVJ. 9, 14 and 19 are read together the meaning becomes clear and natural as explained above. Lok. Tilak wanted to suggest us to read multiplication table of 3 with 9 ascendant sign of 3 nakshatras each. He was not satisfied with his own suggestion. He made the following observations (page 103) :-

"Mr. Dikshit has not translated the first half of the verse. But in several places of his book he has thrown out certain suggestions regarding its meaning, which deserve to be noticed. He has shown that before the introduction of Raashis and along with it the twelve Lagnas, the number of Lagnas was nine, each consisting of three nakshatras. If so, one may interpret the verse as meaning that one should indicate the Lagnas by the (successive) multiples of three (counted) from Shravishtha," without straining the meaning of any word therein. But even this meaning is merely conjectural; and in the absence of any further accurate information about the number and meaning of Lagnas in the pre-Raashi period of Hindu astronomy, Mr. Dikshit was right in leaving this part of the verse unexplained. The Vedaanga rules were intended for ordinary priests; and it is not reasonable to assume that they were originally expressed in any but the simplest language and the simplest manner, consistent with the nature of the subject. True that the Vedaanga has all along been a conundrum to us. But this was due partly to its present fragmentary character, partly to the corrupt state of the text and its technical nature, and partly to our ignorance of the ancient astronomical methods. Thanks to the labours of Thibaut, Dikshit, Barhaspatya and others, these difficulties have been almost overcome. But still, if a verse in the Vedaanga fails to yield any intelligible meaning except by violating the natural construction and meaning of the words used, we may be sure to have missed its true import; and the safest course to follow in such case is simply to record our suggestions, if any, and to leave the verse to be finally deciphered by future workers in the field, rather than try to give by hook or crook, to our work a semblance of completeness it has not really attained. For in spite of the great progress already made, the last word on the Vedaanga is, in my opinion, yet to be

uttered."

Matching lunar periods

The tithi-cycle is called synodical period of the Moon in astronomy while the nakshtra cycle is known as sidereal period of the Moon. We think that sage Lagadha matched both these cycles by simple arithmetical calculations. One may feel that there can be shorter cycles in which these two periods can match i.e. in (i) 8 year cycle (ii) 11 year cycle.

We have seen that the tithi-Ritushesh in a solar-year is 11 tithis and the nakshatra-Ritushesh is 10 nakshatras per year. We find that the nakshatra-Ritushesh in 8 years totals to 10 × 8 = 80 nakshatras. With one nakshatra-leap-year we will have 80 + 1 = 81 total nakshatras as ritushesh. This gives us a ritushesh of three sidereal months because 27 x 3 = 81. However when we make calculation for ritushesh in tithis we find 8 × 11 = 88 tithis as ritushesh in 8 years. Three lunar months are equal to 3 × 30 = 90 tithis. The difference (90 - 88) of 2 tithis does not make it possible to compute 8 year cycle as proximate luni-solar cycle.

If we make similar claculations for a period of 11 years, we find that the astronomical cycle may give us four additional synodical months but it does not give us 4 additional sidereal months, (i.e. nakshatra-months) because 10 × 11 = 110 while 4 × 27 = 108. We thus find a shortage of two nakshatras. We feel, with such double check, that Vedic sages could find a proper proximate luni-solar cycle of 19 years.

The equinox

The Rik. text of Vedaanga Jyotisha provides a method to calculate the tithi of an equinox (विषुवन्) when its ordinal number from the begining of the yuga is given. The relevant verse is RVJ. 31:

विषुवं तद्गुणं द्वाभ्यां रूपहीनं तु षड्गुणं।
यल्लब्धं तानि पर्वाणि तथोर्ध्वं सा तिथिर्भवेत्।। RVJ. 31

literal meaning of the words in first one and half line is as follows ;-

Vishuvam = equinox; tatgunam = its ordinal number.
Dvaabhyaam = double; rupaheenam = minus one,
tu shadgunam = multiply by six,
Yallabadham = what is obtained,
tani parvani = those are parvans.

An illustration will explain the meaning better.

To find the tithi of 10th equinox from the begining of the yuga.

10 × 2 = 20 (Vishuvam tatgunam dvabhyam)
20 − 1 = 19 (rupaheenam)
19 × 6 = 114 (shadgunam) . . . (a)

i.e. 114 parvans end on the 10th equinox. These parvans are solar parvans. The meaning of the last quarter of the verse needs more attention.

"Tathordhvam sa tithir-bhavet"

Apte's Sanskrit dictionary gives the meaning of the word Oordhavam = upwards, afterwards or subsequent. The last quarter of the verse would therefore mean "thereafter it would become a tithi"

The method of obtaining tithi at the end of given number of solar parvanas is given in chapter 4. We have to use RVJ. 4 (निरेकं) and RVJ. 23 (तदर्धं) for that purpose. we proceed from the step marked (a) above in the following manner :-

114, solar parvans have passed from the beginning of the Yuga, *Rashi parvans* are to be found according to RVJ. 4. 114 parvans divided by 12 = 9 semister + 6 parvans.

Rashi parvans = 114 - 9
= 105 parvans (Nirekam dwaadasha)
add 2 parvans = 107 parvans
(dvigunam gatasamdnikam)

Thereafter we apply the rule at RVJ. 23.

107 divided by 2 = 53 $^{1}/_{2}$ tithis (tadardham dinabhaag)
= 3 parvans 8 $^{1}/_{2}$ tithis ritushesh - (b)

Therefore total number of lunar parvans and tithis elapsed from the beginning of the yuga is

114 parvans -------------------- from (a)
+ 3 parvans + 8 $^{1}/_{2}$ tithis --- from (b)

---

117 parvans + 8 $^{1}/_{2}$ tithis --------- (c)

This is the answer according to the concept of 19 year yuga. It is 9th tithi of dark-parvan. (because the number 117 is odd.)

The verse can now be explained as follows :-

> "Double the ordinal number of the equinox, subtract one from the product and multiply by six. What we obtain is (total) number of (solar) parvans. Thereafter it would become a tithi. (by methods given in RVJ. 4 and RVJ. 23)

Those who wanted to imagine five year cycle in Rik-text of Vedaang i.e. Sham Sastri, Kuppanna Sastri, H.M. Yajnik changed the version of the second line replacing (तदार्ध) tadardham for the word (तथोर्ध्व) tathordhvam i.e. "half to those" for "thereafter it" They proceed to calculate in the following manner :-

114 divided by 2 = 57 tithis of ritushesh.
= 3 parvans + 12 tithis -------------------- (d)

They will get the following answer :-

114 parvans -- from (a)
+ 3 parvans + 12 tithis ------------------------------- from (d)

---

117 parvans + 12 tithis.

It appears that S.B. Dixit saw the difficulty in the language (S.B. Dixit vol. I page 82). He used following steps to get the answer.

10 - 1 = 9 9 × 2 × 6 = 108 parvans
9 × 1 × 6 = 54 tithis

108 parvans + 54 tithis = 111 parvans + 9 tithis -------------------- (e)

Adding to this the period elapsed up to first equinox from the beginning of the yuga i.e. 6 parvans 3 tithis.

We get : 117 parvans + 12 tithis ------------------------------------ (f)

(10th equinox, therefore, falls on the 12th tithi of dark half in 118th parvan from the beginning of the yuga).

In this method of calculations, there are two deviations from the proper meaning of the text, they are -

(i). Dixit subtracts one directly from the serial number of the Vishuvan (here ten). This is not according to the sequence of mathematical operations given in the verse.

(ii). Dixit also separately multiplies (10 - 1) by 6 to obtain the number of tithis, which step is not given in the verse. It appears that he does so for giving effect to the implied meaning in the words "(तथोर्ध्वं) thereafter". He then gives his own subsequent method of obtaining ritushesh from parvans (given as second deviation above).

तृतीयां नवमीं चैव पौर्णमासीं त्रंयोदशीम।
षष्ठींच विषुवां प्रोक्तो द्वादश्यां च समं भवत्।।३३।। RVJ 33

Sage Lagadha provides this verse for classification of the years according to the tithi of the Vishauvan day. It is a corollary of RVJ. 8. In RVJ. 8 years are classified according to the tithi of a winter solstice. Here they are classified according to the tithi of Vernal equinox. The serial number of tithi of a Vernal equinox is 3 tithi more than that of its preceeding winter solstice. RVJ. 33 means.

" (i) Triteeyaa (third tithi of bright fortnight) (ii) navamee (ninth of bright fortnight) (iii) Paurnima (full moon-day) (iv) shashthi (the sixth of dark fortnight) (v) dvaadashi (twelfth of dark fortnight) are the limits of tithis for classifying the year according to vernal-equinox on which the solar year begins."

θθθθθ

PART - III

CHAPTER 7

Positions of the Sun and the Moon

RVJ. 10, 11, 12, 13 and 21 are the verses in which mean positions of the Sun and the Moon at the end of each parvan is described in the form of mathematical formula. The ecliptic is divided in a smaller angular unit known as "Bhaamsha" (भ-अंश) for specifying the position of the sun. The position of the moon is described in unit of time-angle called "Kalaa". These are the sub-divisions of a nakshatra. The position of the Moon is also calculated in terms of "bhaamshas" but it is only for an intermediate step.

Basic and normal years

The length of a year was also relevant for this purpose. As stated earlier (page 19) the Rik-cycle consisted 18 years with 371 tithis. Vedic sages knew that the mean solar year consists 365 $^1/_4$ days. However the leap year was presumed to consist of 366 days. Let us call it as "basic year". It was used for defining time units and angular units. In mathematical calculations its constituents were used for a first step of approximation. To obtain the average length of the year as 365.25 days, the length of the other 18 years was reduced to 365 $^5/_{24}$ days. In Western time units it can be expressed as 365 days and 5 hours (365.20833 days). Let us call it as normal year. (see page 31)

Basic year = 372 tithis = 366 days
Normal year = 371 tithis = 365 days, 5-hours
= 365.20833 days.
= 365 days 126 Kalaas (approximate)

Bhaamshas

In the basic year the path of the Sun is divided in 27 nakshatras as well as into 372 tithis. One nakshatra would therefore consist of 372 ÷ 27 124/9 tithis. To avoid fractions sage Lagadha sub- divided the angular distance travelled by the Sun in a tithi into 9 parts called ***Bha-amshas*** **(भ-अंश)** . Let us denote this angular distance as 1 Bh^{o}.

1 tithi = 9 Bh^{o}
1 Nakshatra = 124 Bh^{o}

The angular distance travelled by the Sun in a half-lunation i.e., from syzygy to syzygy (paksha to paksha) is called parvan. Therefore -

1 parvan = 15 tithis
= 135 Bh^{o}

In a year we have $372 \div 15 = 24.8$ parvans. S.B. Dixit had thought that both the texts of *Vedaanga* are based on 5-year luni-solar cycle. He therefore gave 5 tables to show parvan and nakshatra positions of the Sun in five years. These tables are called *Amsha-Saarinees*. The Zero position of the Sun in these tables is at Winter-Solstice in Shravishthaa (Delphinus).(Please see Appendices 3A, B, C, D, E)

From amsha-saarinees (Tables) we get the nakshatra positions of Sun at the end (i.e. joint) of each parvan during its journey in a number of nakshatras and Bha-amshas. Tilak calls them Sun's parvan nakshatras.

Dixit's first year table shows parvan nakshatra positions of the Sun in the basic year. With slight modifications, we have given the amsha-saarnee of the basic year of Rik cycle in Table 5-A.

भांशाः स्युरष्टकाः कार्याः पक्षा द्वादश चोद्गताः ।
एकादश गुण स्योनः शुक्लेर्ध्दं चैन्दवा यदि ॥१०॥ (RVJ 10)

We would first know the meaning by examples and then put it into words.

Example - Find out the parvan nakshatra position of the Sun at the end of the 7th parvan (Please see Table 5-A Column 2, 3, 4.)

Let us denote the angular distance travelled by the Sun in a nakshatra by 'N' so that 124 Bh^{o} = N

$$
\begin{aligned}
1 \text{ parvan} &= 135\ Bh^{o} \\
&= N + 11\ Bh^{o} \\
7 \text{ parvans} &= 7\,(N + 11\ Bh^{o}) \\
&= 7\,N + 77\ Bh^{o}.
\end{aligned}
$$

Therefore, the answer of the above question is : at the end of the

TABLE No. 5-A
Basic Solar Year (RVJ. 10)

	Solar Sidereal Positions				Lunar Sidereal Positions			
Name of the Month	Sr. No. of parvan	No. of complete solar nakshatra	Solar Bh^{o}'s	Name of the solar nakshatra	No. of complete lunar nakashtra	lunar Bh^{o}'s	Total Nakshatras crossed/27 Remainder	Name of lunar nakshatra
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Maagha	1	1	11	Shatabhishaj	14	73	14	Maghaa
Maagha	2	2	22	Poor'Bhaad.	29	22	2	Poor' Bhaad.
Phaalguna	3	3	33	Utt' Bhaad.	43	95	16	Utt' Phaal.
Phaalguna	4	4	44	Revatee	58	44	4	Revatee.
Chaitra	5	5	55	Ashvayuj	72	117	18	Chitraa.
Chaitra	6	6	66	Bharanee	87	66	6	Bharanee.
Vaishaakha	7	7	77	Krittikaa	102	15	21	Anuraadhaa
Vaishaakha	8	8	88	Rohinee	116	88	8	Rohinee.
Jyeshtha	9	9	99	Mriga	131	37	23	Moola.
Jyeshtha	10	10	110	Aardraa	145	110	10	Aardraa.
Aashaadha	1	11	121	Punarvasu.	160	59	25	Utt' shaadhaa
Aashaadha	12	13	8	Aashleshaa	175	8	13	Ashleshaa.
Sharaavana	13	14	19	Maghaa	189	81	27	Shravishthaa

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Shraavana	14	15	30	Poor'Phaalg.	204	30	15	Poor'Phaalg.
Bhaadrapada	15	16	41	Utt.'Phaalg.	218	103	2	Poor'Bhaad.
Bhaadrapada	16	17	52	Hasta	233	52	17	Hasta.
Aashvina	17	18	63	Chitraa	248	1	5	Ashvayuj.
Aashvina	18	19	74	Swaatee.	262	74	19	Swaatee.
Kaartika	19	20	85	Vishaakhaa	277	23	7	Krittikaa.
Kaartika	20	21	96	Anuraadha.	291	96	21	Anuraadhaa.
Maagrasheersha	21	22	107	Jyeshthaa	306	45	9	Mriga.
Maargasheersha	22	23	118	Moola	320	118	23	Moola.
Pausha	23	25	5	Utt'shaadhaa	335	67	11	Punarvasu
Pausha	24	26	16	Shravana	250	16	26	Shravana
Ritushesha	12 Tithis	27	+ 108		361	99	10	Aardraa
			= 124					

7th parvan the Sun was 77 Bh$^{\circ}$ inside the 8th nakshatra i.e. Krittikaa. This is called the sidereal position of the Sun.

When the number of parvans increases more than 12, we have

12 parvans = 12 (Nakshatras + 11 Bh$^{\circ}$)
= 12 Nakshatras + 132 Bh$^{\circ}$
= 13 Nakshatras + 8 Bh$^{\circ}$
(Please see Table 5-A).

Thus the first line and half of the second line of verse 10 can be translated as :-

"In a group of 12 pakshas 8 Bha-amsha arise. For the remainder (i.e. less than 12 pakshas) 11 Bha-amshas (per paksha) arise" (see Table 5-A).

शुक्लेर्धं चैंदवा यदि

We have a full Moon at the end of the first parvan after the beginning of the Yuga. On full-Moon day the moon is diametrically opposite to the Sun i.e. 27/2 = $13\frac{1}{2}$ nakshatra (13N + 62 Bh$^{\circ}$) away from the Sun. During this interval the Sun itself crosses N + 11 Bh$^{\circ}$. The position of the Moon at the end of first parvan is, therefore, (13N + 62Bh$^{\circ}$) + (N + 11Bh$^{\circ}$ = 14N + 73 Bh$^{\circ}$ (See table No. 5-A column 7). At the end of the 2nd parvan we have the Moon's journey = 2 (14N + 73 Bh$^{\circ}$) = 29N + 22 Bh$^{\circ}$. Because the total exceeds 124 Bh$^{\circ}$, we have an additional nakshatra. Thus when we compare the Sun's journey with the Moon's journey only for bhaamshas, (ignoring the nakshatra portion i.e. column 4 with column7) we get additional 62 Bh$^{\circ}$ at the end of an odd number of parvans i.e. on full Moon days. These 62 Bh$^{\circ}$ are equal to a segment of half nakshatra. This is what is stated in a few words in the last quarter of RVJ. 10 (शुक्लेर्धं चैंदवा यदि).

RVJ. 10 can therefore be explained as :-

"In group of 12 *pakshas* 8 bhaamshas arise. For the remainder (i.e. less than 12 pakshas) 11 bha-amshas (per paksha) arise. When you calculate lunar bha-amshas for a parvan ending in full moon-day, add bhaamshas equal to a half nakshatra i.e. 62 Bh$^{\circ}$."

When we divide the entries in column 6 of table 5-A by 27 we get the number of complete rounds made by the Moon in the back ground of stars. From the remainder number (column 8) we get the name of the nakshatra which the Moon occupies at the end of each parvan.

The Normal Year

The basic solar year is made of 372 tithis. Its ecliptic is divided into 372 x 9 = 3348 Bh° (= 360.97°). The normal year is made of 371 tithis. Its ecliptic is divided into 371 x 9 = 3339 Bh° (= 360°). We are, therefore, required to reduce 9 Bh° of length from the ecliptic to make it equal to 360° i.e. equal to 27 nakshatras. This would convert the 5 year cycle into 19 year cycle. Sage Lagaha has provided RVJ. 12 with this object.

त्र्यंशी भशेषो दिवसांश भागः चतुर्दशस्याप्युपनित भिन्नम्।।
भार्धेऽधिके चाधिगते परेंशे द्वावुत्तमैकं नवकैरवेद्यम् || RVJ. 12 ||

If we distribute the shortage of 9 Bh° in 27 nakshatras, each nakshatra would be $^1/_3$ Bh° less i.e. $124 - \frac{1}{3} = 123\frac{2}{3}$ Bh° of angular segment. In table 5-A we calculate the difference in the angular width of the segment of the parvan and that of nakshatra. In a normal year it would be 135 Bh° - $123\frac{2}{3}$ Bh° = $11\frac{1}{3}$ Bh°. We are, therefore, required to amend the entries in column 4 of Table 5-A. In this table we make the calculations of the total Bh°s at the end of each parvan, not at the end of each nakshatra. The author of Vedaanga, therefore, directs us to reduce the total length of nakshatra crossed by the sun at the end of each parvans, i.e. on the 14th tithi of a parvan. (See Table - 5B)

Position at the end of Half Lunar Year

The total number of Parvans in a year are 24.8. The half of the integral number is 12. The sun crosses nearly half of the sky when 12 parvans are over. In Table 5-A column 3 we find that when the sun crosses 11th parvan and reaches the 12th parvan an additional nakshatra is crossed covering two nakshatras, the number of complete nakshatras covered by the sun jumps from 11 to 13. We are, therefore required to deduct 1/3 Bh° twice. (Please see Table 5B) This is how we record the position of the Sun's journey at the end of every lunar fortnight. The meaning of RVJ 12 is, therefore :

"Deduct one third of bhaamsha angular distance from the solar

TABLE No. 5-B
(Normal year RVJ. 12)

Name of the month	Sr. No. of a parvan	No. of complete Selor Nakshatra.	Fraction of Nakshatra (Bh^o) before the of parvan		Name of the month.	Sr. No. of a parvan	No. complete solar Nakashtra.	Fraction of Nakshatra (Bh^o) before the end of parvan	
			RVJ 10	RVJ 12				RVJ 10	RVJ 12
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Maagha	1	1	11	$11\frac{1}{3}$	Shraavana	13	14	19	$23\frac{2}{3}$
Maagha	2	2	22	$22\frac{2}{3}$	Shraavana	14	15	30	35
Faalguna	3	3	33	34	Bhaadrapada	15	16	41	$46\frac{1}{3}$
Faalguna	4	4	44	$45\frac{1}{3}$	Bhaadrapada	16	17	52	$57\frac{2}{3}$
Chaitra	5	5	55	$56\frac{2}{3}$	Ashvina	17	18	63	69
Chaitra	6	6	66	68	Ashvina	18	19	74	$80\frac{1}{3}$

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Vaishaakha	7	7	77	$79\frac{1}{3}$	Kaartika	19	20	85	$91\frac{2}{3}$
Vaishaakha	8	8	88	$90\frac{2}{3}$	Kaartika	20	21	96	103
Jeshtha	9	9	99	102	Maargashirsha	21	22	107	$114\frac{1}{3}$
Jeshtha	10	10	110	$113\frac{1}{3}$	Maargashirsha	22	23	118	$1\frac{2}{3}$
Aashaadha	11	11	121	$\frac{2}{3}$	Pausha	23	25	5	13
Aashaadha	12	13	8	$12\frac{1}{3}$	Pausha	24	26	16	$24\frac{2}{3}$
					Ritushesha	11 tithis	27		99
									$123\frac{2}{3}$

journey (as recorded according to RVJ 10) on the 14th day of each parvan. An additional deduction be made from another (second) set of 9 bhaamshas when the sun crosses half number of parvans"

The word "navaka" in RVJ. 12 means a set of 9 Bh^{o} in other words a tithi. Table No. 5-B would explain the meaning of RVJ 12 more clearly.

Divasaamsha Bhaagah

(दिवसांश भागः)

The words "tryamshibha-shesho divasaamsha-bhaagah" appear in the first line of RVJ. 12. The words "tryamshibhshesho" has been explained earlier. There are no mathematical or astronomical operations given in the text for explaining the words "divasaamsha-bhaagah". The words "divasaamsha bhaagah" literarily mean day-divisions. The Vedic Sages among all other requirements for performance of sacrifices needed the mean time at which each parvan began in terms of number of days and Kalaas from the begining of the year. The words "divsamsha-bhaga" are used for this purpose. Before we proceed with the subject following time units may be noted :-

1 day = 603 Kalaas (कला)
1 Kalaa = 124 Kashthaas (काष्ठा)
1 Kashthaa = 5 Akshara (अक्षर)

The aim 4 giving verses RVJ. 10, 11, 12 and 13, as now commonly accepted, is to provide the number of nakshatraas covered by the Sun and the Moon at the begining of each parvan. They are commonly known as solar-nakshatras and lunar-nakshatras. The object would remain only partially achieved if we do not know when each parvan in the year begins. The method of finding the time of beginning of each parvan in the year is as follows.

The ratio of the total number of tithis to the total number of days in first 18 years of the Rik-cycle is about 64/63.

$\therefore$ 64 tithis $\cong$ 63 days

Denote the length of day minus the length of the tithi by
1 Db (a day-division)

so that 1 Db $\cong \frac{1}{64}$ day

$\therefore$ T tithis = T (1 day - 1 Db)
$\therefore$ 1 Parvan = 15 (day - Db)
$\therefore$ n Parvans = 15n (day - Db)

Better value of Db can be found in the following nammer:-

$$\text{One Db} = \frac{371 - \text{total number of days in a year}}{371}$$

$$= \frac{371 - 365.20833}{371} \text{ days}$$

$$= 9.4127 \text{ Kalaas}$$

$$= 9 \text{ Kalaas } 51 \text{ Kaasthas}$$

$$\text{also 1 day} = 64\frac{1}{16}\ Dbs$$

(Note :- There was no system of calculations in decimal fractions during Vedaanga period. Yet calculations were made in smaller time units like Kaashthas, Aksharas, Palas and Vipalas)

RVJ. 12 has therefore double purpose.

It gives lengths of arcs of parvans in terms of Solar nakshatras and bhaamshas as also their lengths of time in number of days and Kalaas.

We should make the adjustment of time "Divasaamsha bhaagah" only once at the end of parvans though we count at some places an increase of 2/3 bhaamshas as given in table 5-B. The rule therefore operates only at the end of each parvan and at the end of the year. The total deduction in 15 days is 141.19 kalaas so that, 15 tithis = 15 days – 141.19 kalaas.

We can find out the decayed or dropped (क्षय) tithis in the cycle from the meaning of the word "divassamsha bhaagah" as given above. The 64th tithi after the laps of each group of 63 tithis should be counted as decayed. After repeating the operations 15 times 1025th tithi should not be dropped because a day = $64\frac{1}{16}$ Dbs. The author of Vedaanga Jyothisha has not given this rule of decay of tilhi separately because it was not necessary for the purpose of performing the sacrifices.

We have earlier given the explanation of the verse RVJ. 12, But it does not include the meaning of word divasaansabhaga. It is therefore necessary to modify its meaning. We have the following explanation of RVJ. 12.

"Deduct one divasaamsha-bhaga per tithi and also deduct one- third of .bhaamsha angular distance from the 14th tithi of each parvan. An additional deduction be made from another (second) set of 9 bhaamshas when the Sun crosses half number of parvans (in the year)".

Bhaamshas and Javadi

Dixit gave tables for comparison of lengths of parvans and nakshatras to explain RVJ. 10. They are given in Appendix 3 A-B-C-D and E of this book. We find from Column 4 of these tables that parvans are longer than solar nakshatras by 11 Bh. This column therefore shows multiples of 11. It appears that Dixit was in search of the object of providing Javadi list RVJ. 14 (Jaudragah जौद्राघः). RVJ. 14 provides a list of nakshatras with rearranged serial order, by skipping over 5 nakshatras. In a way it is multiplication series of 5. He suggested the probability of relevance of Javadi list with RVJ. 10 because if we divide the number of Bh^{o} in column 4 of Appendix 3 by 27 we get the numbers 1, 2, 3, 4 at serial numbers of parvans 5, 10, 15 - - and so on in the Javadi list. We get them in column 6 of Appendix 3. (Please see Dixit's book page 27 Vol 1). However Dixit makes a remark "the scheme or system cited above cannot be rightly understood". It appears that he said so because he could not show its relevance with the purpose of the text. Readers can appreciate two important products of numbers, 11 x 5 = 55 while 27 x 2 = 54. The difference in these products is 1. This is the reason why we have peculiar type of entries in column 6 of Appendix 3. Those entries have no other relation with Javadi list. It is because of the product 11 and 5, Lok. Tilak tried to show the relevance of Javadi list with YVJ. 20. "Tithimekadash" (तिथिम् एकादशभ्यस्तां - - - - -). But Rik-text of VJ. does not provide any such verse. Prof. Kuppana Sastri and Dr. Yajnik, perhaps gave importance to the number 5 in the product 11 x 5 = 55. They show that we can get the name of solar and lunar nakshatra by using the corrosponding Bh^{o}s in amasha saarini, by dividing them by 27, then using the balance as serial number in Javadi list. This is how they indirectly suggest that RVJ 14 is in a way a converse proceedure to RVJ. 10. The hand-book of Vedaanga has a definite purpose. It is not simply meant for mathematical excercises, or for exibiting mathematical skill. Dixit has therefore rightly reserved his comment and did not show nexus of RVJ. 10 with RVJ. 14. and the purposes of any such relation.

When we turn to RVJ. 19 (श्रविष्ठाभ्यां - - - -) its first line shows that it needs some multiplication series to complete its explanation. Lok. Tilak suggests that it is of Three. He feels that his suggestion of the number is only hypothetical. We find it to be series of multiples of 5 in Javadi list. The matter then becomes as clear as crystal, because one of the object of RVJ. 19 is to find out the names of nakshatras of successive solstices, which we get directly by using these two verses. The explanation needs no amendment to RVJ. 19.

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CHAPTER 8

Kalaas and Naadikaas

From table 5-A we get the positions of the Sun at the end of various parvans in nakshatras and Bh°. The time of the entry of the Moon in current nakshatra may not be same as that of the sun. The moon moves faster than the sun. The time of the entry of the moon in the current nakshatra is measured in days and kalaas from the beginning of the yuga. Before we calculate it, we should know some more time units. Let us know what are kalaas.

कला दश च विंशा स्याद् द्विमुहूर्तस्तु नाडिके ।
द्वित्रिंशस्तत्कलानां तु षट्शतीत्र्यधिकंभवेत् ।।१६।।

Meaning - Naadi = (10 + 1/20 kalaa)

Muhoorta = 2 naadis

1 day = 30 Muhoortas = 603 Kalaas

The following ratios of the time units are derived for recording the positions of the moon in the sky.

1 day = 603 kalaas.

1 tithi = 593 + 17/62 kalaas.

Time taken by the moon to cross one nakshatra is 610 kalaas. Let us denote the time unit Kalaa by Kl.

Bhaadaana Kalaas

There is a separate thumb rule provided in RVJ. 21 for the purpose of calculating the time taken by the moon to cross a given number of nakshatras.

याः पर्वभादानकलास्तासु सप्तगुणां तिथिम् ।
प्रक्षिपेत् कलासमूहस्तु विद्यादादानकीः कलाः ।। RVJ-21 ।।

Let the number of nakshatras which the moon has to cross be R. Then the time required by the moon to cross R nakshatras.

= R x 610 Kls.

= R (603 + 7) Kls.

= 603 R + 7 R = R days + 7 R Kls.

Thus for crossing 9 nakshatras the moon would require 9 days and 63 kalaas. These surplus kalas are called Bhaadaana kalas.

Bhaadaana Kalaas at the End of Parvans

Now we turn to RVJ 11

कार्यभांशाष्टकास्थाने कला एकान्नविंशतिः ।
ऊनस्थाने द्विसप्ततीः उद्वपेदूनसंमिताः ।।११।।

Just as Vadaanga provides verse 10 for finding out the angular position of the Sun at the end of each parvan, it provides verse 11 (equal to YVJ. 19) for calculating the time of the entry of the moon in the last nakshatra on the relevant day at the end of various parvans. Tilak has explained, from elementary principles, how to calculate these Bhaadaana Kalaas.

The Sun takes $13^5/9$ days to traverse one nakshatra, while the moon takes 1 day and 7 kalaas to traverse a nakshatra. We know that in one paksha the moon traverses an angular distance equal to 14 N 73 Bh°. Out of this 14 nakshatras are crossed by the moon in 14 x (days + 7 kalaas) = 14 days + 98 kalaas. We are therefore required to calculate the number of complete nakshatras, which the moon has crossed at the end of each parvan, and then multiply the number by 7 to get the total number of kalaas. Thus at the end of the 16th parvan (see table 6-A) the moon (after completing various rounds of 27 nakshatras each) is noted to have crossed a total 233 nakshatras from the beginning of the yuga. That means 233 days + 233 x 7 kalaas are taken by the moon to reach the end of the 233rd nakshatra, which are equal to 235 days and 425 kalaas. Presume that the day began at mean time of Sunrise in the morning (6 AM) then, on 236th day the moon entered the 234th nakshatra after a lapse of 425 kalaas after Sunrise at the end of the 16th parvan.

In RVJ. 11 the Vedic sage has tried to give a thumb rule to calculate the bhaadaana kalaas at the end of a given number of parvans. To explain the thumb rule, Tilak was required to use three verses viz. 11, 12 and 13 with a number of mathematical operations. Hence it cannot be called a

TABLE No. 6 - A

Month	Sr. No. of the paksha	Sr. No. of last lunar nakshatra	Lunar Bh°	Bhamshaashtaka	Kalaas of a previousday	Oonasthane Udwaped	Dwisaptateehna Sammita
	1	2	3	4	5	6	7
Maagha	1	14	73	$9^1/8$		171-73	98
Maagha	2	29	22	$2^6/8$	603 +	38-438	203
Phaalguna	3	43	95	$11^7/8$	603 +	209-511	301
Phaalguna	4	58	44	$5^4/8$	603 +	95-292	406
Chaitra	5	72	117	$14^5/8$	603 +	266-365	504
Chaitra	6	87	66	$8^2/8$		152-146	6
Vaishaakha	7	102	15	$1^7/8$	603 +	19-511	111
Vaishaakha	8	116	88	11		209	209
Jyeshtha	9	131	37	$4^5/8$	603 +	76-365	314
Jyeshtha	10	145	110	$13^6/8$	603 +	247-438	412
Aashaadha	11	160	59	$7^3/8$	603 +	133-219	517
Aashaadha	12	175	8	1		19	19
Shraavana	13	189	81	$10^1/8$		190-73	117
Shraavana	14	204	30	$3^6/8$	603 +	57-438	222
Bhaadrapada	15	218	103	$12^7/8$	603 +	228-511	320
Bhaadrapada	16	223	52	$6^4/8$	603 +	114-292	425
Aashvina	17	248	1	$^1/8$	603 +	-73	530
Aashvina	18	262	74	$9^2/8$		171-146	25
Kaartika	19	277	23	$2^7/8$	603 +	38-511	130
Kaartika	20	291	96	12		228	228
Maargasheersha.	21	306	45	$5^5/8$	603 +	95-365	333
Maargasheersha.	22	320	118	$14^6/8$	603 +	266-438	431
Pausha	23	335	67	$8^3/8$	603 +	152-219	536
Pausha	24	350	16	2		38	38
Ritushesha	12	361.8	99				

$$\left.\begin{array}{l}11\ \text{N} = 77\ \text{Kls}\\ +8\ \text{Nakshatra} = 488\text{Kls}\end{array}\right\} = \frac{565\ \text{Kls}}{603\ \text{Kls}}$$

thumb rule.

Prof. T.S. Kupanna Sastri has given a consistant explanation of this verse. I am giving it in my own words. (Please see table 6-A when we read the explanation).

Meaning of Verse 11 :-

"Substitute 19 kalaas for every group of 8 Bh$^{\circ}$ (Bhaamshas) in a table prepared for solar position. Then subtract 72 times the remainder Bh$^{\circ}$ (when the remainder occurs) along with the remainder Bh$^{\circ}$."

The words द्विसप्तती: उद्वपेद् ऊनसंहिता: are explained by Tilak "as 72 times the remainder along with the remainder" ultimately meaning "73 times the remainder". The words are interpreted by him as at odd places", while Prof. Kuppanna Sastri interprets them as "on the negative side". The verse will now mean "Substitute 19 kalaas for every group of 8 Bh$^{\circ}$. Then subtract Kalaas equal to 73 times for the remainder f Bh$^{\circ}$". The meaning would be clear from the following examples.

Example : Calculate the time in kalaas of the moon's entry on a new moon tithi at the end of the 6th parvan.

We have 66 Bh$^{\circ}$ in the moon's position at the end of the 6th parvan (See table No. 6 A Col. 3). Let us convert these into octads $66 \div 8 = 8^{2}/_{8}$. We have 8 octads and 2 Bh$^{\circ}$ as remainder. When we apply the rule of verse 11, we have (8 x 19 - 2 x 73) kalaas. That is the time of day of the moon to transit from one nakshatra to the other. It is equal to (152 - 146) = 6 Kls (see col. 7).

Example : Calculate the time in Kls. of the moon's entry in the new-moon position at the end of the 4th parvan.

We have 44° at the end of the 4th parvan $44 \div 8 = 5^{4}/_{8}$ (5 octads and 4 Bh$^{\circ}$). Required Kls. are therefore (19 x 5 - 4 x 73) = 95 - 292 Kls. The answer may turn negative. We therefore require kalaas from earlier day. Hence (603 + 95 - 292) = 406 Kls.

In Prof. Kuppanna Sastri's method, we do not get the number of days that have lapsed from the beginning of yuga, but they can be independently found by using the formula :

1 day = 61/62 Tithi.

* * * * *

CHAPTER 9

Kalaas and Normal year

While preparing table No. 6-A for calculating Bhaadan kalaas, we presumed the length of the solar year as 366 days i.e. 372 tithis. The length of the year was known to the ancient civilisations as 365.25 days. It was, therefore, necessary to find out bhaadan kalas with respect to days and lunar nakshatras in civil year consisting 365.25 days and 361 nakshatras. However the last year of the 19 year cycle was a leap year. The length of the normal year was therefore, presumed to be slightly less.

We know that the normal year had, a length of 365.20833 days. (of 365 days and 126 Kalaas i.e. five hours (see page - 50). If we convert these days into kalas and divide the result by 361 nakshatras we get the length of lunar nakshatra as 610.02942 kls. While preparing table No. 6-A we presumed that the moon takes only 610 kls. of time to cross one nakshatra. Table No. 6-A, therefore needs modification to record the cumulative effect of additional .02943 kls. per lunar nakshatra. According to us this object is achieved by RVJ. 13.

पक्षात् पंचदशात् चोर्ध्वं तद् भुक्तमिति निर्दिशेत् ।।
नवभिस्तुद्गतोंशात् उनांशादूयाधिकेन तु ।। RVJ-13 ।।

If we go through the entries in column 7 of Table No. 6-A we find that the number of kalaas mentioned in the column increase in multiples of seven per nakshatra. The difference in bhaadan kalaas of nakshatras of the two types of years (basic and normal) was therefore ignored till the total reached seven kalaas.

The author of the Vedaanga Jyotisha directs us to count additional seven kalaas after a lapse of 15 parvans and 9 nakshatras. These nine nakshatras are covered by the moon in 9 days and 63 kalaas. At the end of 15th parvan Moon covers 218 nakshatras (Col. 2 of table 6-A). A further coverage of nine nakshatras makes the total passage as 227 nakshatras. Bhaadan kalaas for 227 nakshatras are therefore 227 x 7 = 1589 kalaas. After deducting kalaas for two complete days we have 1589 - (2 x 603) = 383 kls. If we follow the direction given in RVJ. 13 we have to add seven kalaas more and make the total number of bhaadaan kalaas as 390 kalaas after Sun-rise on the relevant day (see Table 6B). However such an addition of seven kalaas at the end of 227 nakshatras of lunar journey

TABLE No.-6 - B

Month and tithi	Sr. No. Parvan	Sr. No. Last Luaar nakshatra	Col. 7 Table 8	As per RVJ 13	Bhaadan Kalas
1	2	3	4	5	6
Bhadrapada sk. 15	15	218	320	+ 7	320
Bhadrapada Vd. 9	--	227	383	+ 7	390
Bhadrapada 30	16	232	425	+ 7	432
Ashvin Sk. 15	17	248	530	+ 7	537
Ashvin Vd. 30	18	262	25	+ 7	32
Kaartika Sk. 15	19	277	130	+ 7	137
Kaartika Vd. 30	20	291	228	+ 7	235
Maargashirsha Sk 15	21	306	333	+ 7	340
Maasrashirsha Vd. 30	22	320	431	+ 7	438
Push Sk. 15	23	335	536	+ 7	543
Push Vd. 30	24	350	38	+ 7	45
Ritushesha	11 tithis	361		(11N × 7)	+ 77
					122

is equivalent to 7 ÷ 227 = 0.030837 kalaas per nakshatra. Let us call this correction in the computation of lunar journey as "RVJ. 13 correction". It means the Moon takes 610.030837 kalaas to cover one nakshatra. The total number of bhaadan kalaas shown at the end of column 6 of Table 6 B i.e. 122 kalaas does not include the additional kalaas due to "RVJ. 13 corrections" after 227 nakshatras till the end of the year. It totals to 4.1322 kalaas. Thus at the end of the year we have in all 126.1322 bhaadaan kalaas. Discarding the fraction we find the year ending with 126 kls. It is worthwhile to note that the number 126 is divisible by seven. These 126 kls. should be shown in the balance-sheet of time to be prepared at the end of an year, increasing at the same rate every year. The literal meaning of the sanskrit words in RVJ. 13 is as follows :

Pakshaat : from a parvan ; **Panchadashaat** : from 15th ; **Chordhyam** : subsequently; **tat** : they ; **Bhukta** : are consumed ; **iti** : like this ; **nirdishet** : indicate ; **navabhihi** : by nine (days) **udgata** : rising ; **Unaamsha** : the portion of the difference (in this case 610 - 603 = 7 kalaas)

dvyadhikena : by adding two times.

Meaning of RVJ. 13 :

> "Record that they (time in bhaadan kalaas) are consumed (in lunar journey) till the end of 15th parvan (as explained in RVJ. 11). Subsequently, after the rising of nine days add the portion of the difference (i.e. 610 - 603 = 7 kalaas) two times".

Thus 227th lunar nakshatra has a length of 603 + 2 x 7 = 617 kalaas. (It is longer than other nakshatras by seven kalaas).

Critical Remarks on RVJ. 13

The wordings of RVJ. 11 and YVJ. 19 are similar. Their purpose is the same. There is no verse in Yajus text like RVJ. 13 either with similar words or for the same purpose, because Yajus cycle is a quinquennial cycle. Its author does not intend to modify it and make it suitable for 19 years luni-solar cycle. Kuppana Sastri treats RVJ. 13 Pari materia with YVJ. 16 (pages 54 - 55). YVJ. 16 begins with the words "Navakair udgatomshah (नवकैरुद्गतोंशः) ". According to him the object in providing the said verse is to give the sum of the angular distances of Shravistha and the Sun from orient point at the end of each parvan in a yuga. This object appears to be more technical than those for which RVJ. is composed i.e. to know before hand the tithis and nakshatras of the days of solstices and syzyagies and to know bhaddan kalaas on the days of syzyagies. Prof. Kuppanna Sastri explains RVJ. 13 "Pakshat panchdashat chordham -- पक्षात् पंचदशाच्चोर्ध्वम् " with the words "After 15th tithi ---" contrary to the plane sanskrit meaning "After 15th paksha (parvan)". This shows that RVJ. 13 has no resemblance with YVJ. 16. Its purpose and explanation has to be different. Lok. Tilak uses RVJ. 11, 12 and 13 to find out bhaadaan kalaas. Prof. Kuppanna Sastri has shown that RVJ. 11 is a complete rule for the said purpose. Tilak translates the aforementioned words as "from the 15th paksha onwards" (page 73). His translation of this part of the verse may be correct but the purpose is obviously wrong.

Dr. Sham Sastri reads these relevant words as "At the end of 15th full-moon-days" i.e. "29th parvan" because the lunar bhaamshas on the said day are nine, and the second line of RVJ. 15 begins with the words नवभिस्तूद्गतोंशः . Thus we do not have a satisfactory explanation from any scholar supporting a quinquennial yuga theory. Readers would appreciate the simple explanation given by us of RVJ. 13 which supports 19 year cycle.

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CHAPTER 10

Zero Error at the Beginning of Yuga

The last step given by Lagadha for harmonising the calendar with actual astronomical position of the Sun and the moon is in RVJ. 34 (**चतुर्दशीमुपवसतस्तथा**). Here the great sage tells us to watch the position of the moon before the dawn of the last day of the last month Pausha of a 19-year yuga. It is a day of Krishna chaturdashee (end of the 29th tithi). The moon is just above the rising Sun in the east when the day dawns, it then moves towards the Sun forming a new-moon day. This event may also occur a day earlier or a day later than the calculated day due to the difference of time accumulated at a very minute rate. It needs to be corrected.

चतुर्दशीमुपवसतस्तथा भवेद् यथोदितो दिनमुपैति चंद्रमाः ।
माघशुक्लह्निको युंक्ते श्रविष्ठायां च वार्षिकीम् ।। RVJ. 34 ।।

In the first line Lagadha describes the last day of the month of Pausha to be fixed by observation. In the second line he gives the description of the astronomical position of the Sun and the Moon on the next day i.e. the first day of the month of Maagha of the new Yuga.

"On the (Krishna) chaturdashee day when the moon is found just above the rising Sun (**उपवसतः**), then as the day dawns, presume that it is with (**उपैति**) the Sun (indicating the new-moon day). The year (thereafter) begins (on the next day) with shukla paksha, the Sun and the Moon *Shravishthaa* (nakshatra)".

The first line gives description of the Moon 12° behind the zero point of the month, while the second line gives the description of the Sun and the Moon at the zero point.

NOTE : (i) In the scheme of Rig Jyotisha calendar, a yuga begins after 15 tithis from the aforementioned day of astronomical observations i.e. on Maagha shukla paurnimaa. For further details please see the chapter on Antiquity.

(ii) This verse is not included in Yajus - text because we do not find the sidereal positions of the Sun and the Moon at the end of a 5 year cycle, as given in this verse.

Ambiguous Verses

When a word or a sentence in a text gives more than one meaning, a difficulty arises in its interpretation. In such cases it is verified which of the meanings suits the object of the author of the text in composing it, and the meaning which is consistent with other part of the text. If it expresses the intention of the author, it is accepted.

There are two lines in Rik-text to Vedaanga which give double meaning. They are 1st line of RVJ. 1 and 2nd line in RVJ. 32. The first line of RVJ. 1 reads.

पंचसंवत्सर मयं युगाध्यक्षं प्रजापतिं

Pancha samvatsaramayam yugaadhyakshyam Prajaapateem.

The word "Samvatsara" in this line has double meaning. It means (i) any solar-year (ii) one of the five types of years as classified in Vedaanga. In the first case it is a common noun, in the latter case it is a proper noun.

The author does not directly say that it is "a yuga of five years". Had it been so he would have called it "panchasamvatsara-yuga". He uses a adjective "mayam" which means "consisting of". So that there can be other types of years, Parivatsaras, Anuvatsaras, Idvatsaras etc along with five Samvatsaras in a yuga, the astronimical chain may be longer even up to 19 years to accomodate five Samvatsaras. (See Tables No.s 2 and 5 on pages 34 and 45 respectively).

We have examined that the text without any amendment, has a base of 19 years. Actual astronomical observations also reveal that the first approximation of such a cycle is of 19 years. The object of the author must be to use an actually verifiable cycle, and not to give a short lived hypothetical cycle which may differ with actual astronomical verification. The five year cycle presumes five solar-years covering five winter solstices in 62 lunar months. 5 solar-years = 1826.21 days and 62 lunar months = 1830.9 days. The difference of about 4.69 days could be marked by an astronomical observer within 10 or 15 years. It is worthy to note that RVJ. 34 provides a method of actual astronomical observation for watching the ends of the yuga. The theory of five year cycle is therefore inconsistent with the object of the author in providing Rik - text.

The second debatable verse is RVJ. 32.

A. माघशुक्ल प्रवृतस्य पौष कृष्ण समापिना।।
युगस्य पंचमस्येह कालज्ञानं निबोधत ।।३२।।

These lines are from Bhatotpalas reading. (See S.B. Dixit Vol. I, page 94.)

Following lines are from Nirnaya Saagar's print "shadanga".

B. माघ शुक्ल प्रवृतस्तु पौष कृष्ण समापिना।।
युगस्य पंचवर्षाणि कालज्ञानं प्रचक्षते ।।३२।।

The real difference is in the first half of the second line
(A) "Yugasya panch-masyeh" and (B) Yugasya pancha-varshani

Bhatotpalas text (marked A) indicates that the fifth yuga begins with a tithi in bright parvan of Maagha month and ends with a tithi in dark parvan of Pausha month. In Table No. 2, in the chapter "classification years" in this book we find that there are five sub-yugas beginning with the year Samvatsara in 19 year cycle. The last sub-yuga begins with 15th year and ends with 19th year. This sub-yuga begins with "Maagh Shukla 5th and ends with Maagha Krishna 30th.

Now let us examine the verse marked B. This verse shows that the yuga consists of five years. It begins with a tithi in bright parvan of Maagha month and ends with a tithi in dark parvan of Pausha month. If we begin the set of five years when we observe winter solstice on first day of Maagha month, the last winter solstice at the end of five years would occur on 1826th day and new moon would be on 1831st day. The last winter solstice therefore occurs five days before the end of the month i.e. on 11th tithi of dark parvan of pausha month. The next cycle has to begin thereafter on 12th tithi of dark Pausha. It is therefore impossible to get three consecutive yugas as defined in the verse marked B. We are therefore constrained to accept Bhatotpalas version (marked A) which indicates a base of 19 year luni-solar cycle. It is consistent with other part of the text. We must presume that the text was in correct form in earlier part of the history. Bhatotpala lived in or about 966 A.D. i.e. about 1000 years ago. This also supports our conclusion that the author of Rik-text of Vedaanga intended to base his work on 19 year luni- solar cycle.

Emendations or Transformation

The earliest commentary on Yajus-text is that of Somakára. According to Yajnik, Shesh Somakara flourished before 8th century A.D. (H.M. Yajnik Introduction page 1). Dixit says "Those verses which are not easy to understand or those which deal with mathematics are left aside (by Somakara). There is no harm if one thinks that Somakara did not understand the work at all. Few astronomers appear to have attempted to explain the mathematical side of Vedaanga Jyotisha" He further adds. "In 1879 Thibaut published a booklet on the translation of Yajur Veda Jyotisha which shows that he could succeed in explaining six verses more than what Somakara could do." (page 66, S.B. Dixit Vol. I). This booklet consisted a part of his article "Contribution to the explanation of Jyotisha Vedaanga" published in the "Journal of Asiatic Society of West Bengal 1987". Thibaut explained YVJ. 1 to 10, 18, 21, 24, 28 to 40. From this set of verses one finds that YVJ. 28, 29, 30, 31 clearly indicate that the quinquennial luni-solar cycle is used by the author of Yajus Jyotisha for preparing the text. What is relevant for us is that the effort to understand the mathematical portion of both the texts of Vedaanga Jyotisha is very recent and because Yajus astronomy is based on five year luni solar cycle scholars presumed that Rik-astronomy is also based on five year luni-solar cycle. Kuppanna Sastri gives a list of 35 emendations found in different critical editions of Rik text (page 26) Out of these 14 emendations, dealing with mathematical portion change the nature of the text. The following table would reveal how the drastic changes suggested by them has defaced the text. RVJ. 13 begins with the words "पक्षात् पंचदशात् चोर्ध्वं" which means after 15 *parvans* (पर्वन) Scholars have translated these words as "After 15 tithis" to suit their explaination (Prof. Kuppanna Sastri page 55, H.M. Yajnik page 29). Lok. Tilak has translated these words as "after 15 *parvans*". However he has treated this verse as third step for calculation of Bhaadaan Kalaas for a five year cycle. But Kuppana Sastri has shown that only RVJ. 11 is sufficient for the said purpose. Hence RVJ. 13 becomes redundant. We have seen that RVJ. 13, with its natural meaning of sanskrit words, shows that its purpose is to modify the results of RVJ. 11 and get final answer in Bhaadaan Kalas for 19 year luni-solar cycle. The 14 emendations pointed out above show that we do injustice to the author of the Rik-text of Vedaanga Jyotisha. These emendations transform the base of the text from 19-year luni-solar cycle to 5-year luni-solar cycle.

There are 36 verses in Rik-Jyotisha, out of which six verses are not

Sr. No.	Particulars	Originals	Amendments
1	2	3	4
1	RVJ. 4	अर्ध अद्धं	अभ्यस्तं
2		संज्ञिकं	संयुतं
3	RVJ. 8	द्विगुणं	प्रथमम्
4		पंचनभस्तृतु	पंचमभस्तृतु
5	RVJ. 12	चाधिगते	चापिगते
6		उत्तमेकं	उत्तमेतत्
7	RVJ. 19	श्रविष्ठाभ्यां	श्रविष्ठायां
8		गुणाभ्यस्तान्	गणाभ्यस्तान्
9		प्राग्विलग्नान्	प्राग्लनान्
10		सूर्यान्	स्तृयान्
11	RVJ. 24	भूयोप्येनं	भूयोप्यन्हः
12		राशिषु	राशिना
13	RVJ. 31	तथोर्ध्वं	तदार्ध
14	RVJ. 13	treating 15 Pakshaas as 15 tithis in the explanation.	

included in Yajus-text. They are RVJ. 2, 13, 19, 29, 33 and 34. Out of these six verses RVJ. 2 and 29 refer to sage Lagadha for exibiting reverance to him and for disclosing his name as a source of knowledge. His name was not included in original Yajus-text.

RVJ. 34 deals with the subject of actual observation of the sky at the end of 19 years in early morning on Paush Krishna chaturdashi in the day of winter solstice. It is obvious that he who wants to write about five year Luni-solar cycle cannot find the astronomical positions of the Sun and Moon as stated in the verse. He, therefore, droped the Verse from Yajus-text.

RVJ. 13 and 19 deal with mathematical operations. We have seen in this chapter how it was difficult to explain these two verses on the basis of five year cycle and how these verses along with five other verses were amended by scholars to suit the meaning which they imagined. It is therefore, clear that the scholars have transformed the text of Rik-Jyotisha to suit their theory of five year cycle.

* * *

CHAPTER 11

Translation of the Rik Text

One of the objects of writing this book is to prove that the basis of Rik text of Vedaanga Jyotisha is 19-year luni-solar cycle. It is therefore necessary to give a translation of the complete text to demonstrate that there is nothing repugnant to our theory in the verses which are not so far explained. Most of the verses in the text are in the nature of mathematical formulae. In Sanskrit there is a peculiar style of writing mathematical formulae. A literal translation of such verse in English would be meaningless. Insertion of some supplimentary words in the translation of the verse and some explainatory notes are necessary. We have given explainatory notes for the verses which are not so far explained. It is worthy to mention here that Tilak, Dixit and Kuppanna Sastri have also inserted such supplimentary words in their translations wherever they thought it necessary.

RVJ. - 1

Oh, *Prajapati,* thou are the lord of cycles yuga consisting of five *samvatsaras.* Your organs are days, seasons, semesters and months. I bow before thee with bent head and pure mind.

RVJ. - 2

Having saluted time, I bow with bent head before Saraswati (the deity of knowledge). I explain the knowledge of time as narrated by the great sage *Lagadha.*

RVJ. - 3

I explain the movement of the luminaries of the heaven (the Sun and the Moon) as they are known to the people from the past and (mathematically) known to the priest ready for performing sacrifices.

RVJ. - 4

Subtract one (parvan) from twelve (Solar parvans) in each semester. Assume two parvans (as balance from) previous (yuga).

Group of sixty parvas inclusive of (aforementioned) two are called Raashis.

RVJ. - 5

"It is sun lit sky (dawn). The moon and the sun are on either side (of the sky). If the sun covers *Shravishtha (Vasava nakshatra),* the yuga and the month Tapah begin (on the day of winter solstice), when the moon passes over the full moon day."

RVJ. - 6

"The sun and the moon turn towards North in the beginning of *Dhanisthas* and towards South in the middle of *Aslesa.* The sun always does this respectively in the months of Magha and Sravana." (Dixit)

Note :- Please see the chapter on antiquity.

RVJ. - 7

When the Sun moves up (northward) heat increases and also increases the length of the day by [illegible] measure of water. During southward course, there is reverse action. The difference in the length of the extreme days is six *muhoortas.*

RVJ. - 8

Years can be divided into five classes according to the beginnings of *ayanaas* (semester of solar years). Such beginnings of the ayanas fall in *shalahas* which begin with (i) 1st tithi (ii) 7th tithi (iii) 13th tithi of bright fortnight and (iv) 4th tithi (v) 10th tithi of the dark fortnight.

RVJ. - 9

"Those *nakshatras* whose lords are *Vasu, Tvashtaa, Bhaga, Aja, Mitra, Sarpa, Ashvini, Jala, Dhaataa* and *Brahmaa* (i.e. Dhanisthaa - Chitraa, Aardraa, Poorvaa Bhaadrapadaa, Anuraadhaa, Ashleshaa, Aashvayujaa, Poorvaashaadhaa, Uttaraa-Phalgunee and Rohinee), were at the beginnings of the segments of the ecliptic as lunar nakshatras which classify the ayanas (solar semesters). They form a half of the five divisions of *ritushesha* in terms of nakshatras.

RVJ. - 10

In a group of 12 *pakshas* 8 *bha-amshas* arise. For the remainder (i.e. less than 12 pakshas) 11 bha-amshas (per paksha) arise. When you calculate lunar bha-amshas for a parvan ending in a full moon day, add bhaamshas equal to a half-nakshatra i.e. 62 Bh^{o}.

RVJ. - 11

Substitute 19 kalaas for every group of 8 Bh^{o} (bha-amshas) in a table prepared for solar-positions. Then subtract 72 times the remainder Bh^{o} (when the remainder occurs) along with the remainder Bh^{o} (i.e. Subtract kalaas equal to 73 times the remainder number of Bh^{o}). This gives the table of time of entry of the moon in next nakshatra at the end of a parvan.

RVJ. - 12

"Deduct one divasaamsha-bhaaga (Db) per tithi and also deduct one third of bhaamsha angular distance from the 14th tithi of each parvan. An additional deduction (of $\frac{1}{3}$ bhaamsha) be made from another (second) set of 9 Bhaamshas when the sun crosses half number of parvans in the year".

RVJ. - 13

"Record that they (time in bhaadaan kalaas) are consumed (in lunar journey) till the end of 15th parvan (as explained in RVJ 11). Subsequently after the rising of nine days add the portion of the difference (i.e. -- 610 - 603 = 7 kalaas) two times".

RVJ. - 14

Note : If we rearrange the list of nakshtras by skipping over five nakshtras every time and indicate them by symbols we get verse 14. जौद्राघः खेश्वे हीरोषाचिन्मुषण्यः

RVJ. - 15

"Know that Javaadi list (RVJ 14 जौद्राघः) is balanced. Former (letter) is for the lunar nakshatra at the beginning of the first half-year; the latter is for the latter half. Bha-amshas and bhaadaana kalaas are to be adjusted at the ends of 14th tithis (for computing the exact number of days in solar years).

Note :- The last quarter of this verse is काष्ठानांदेविनाकलाः The text is thousands of years old. This portion of the text is in the then current Sanskrit language. We can only guess and tell the meaning of this portion. It may be "the last kalaa of the solar year (126th) leaves no fraction which can be measured in *kasthaas*.

RVJ. - 16

(The time measure) *naadikaa* is equal to ten plus one- twentieth *kalaas* (10 + 1/20). Two *naadikaas* make one *muhoorta*. Thirty *muhoortas* or twice the number (30 × 2 i.e. sixty) *naadikaas* make a day which is equal to 603 *kalaas*.

RVJ. - 17

A *muhoorta* is equal to two *naadikaas*. An *aadhaka*, a measure of volume, is equal to 50 *palas*. A *drona* is equal to 4 *aadhakas*. A *drona* exceeds one *naadikaa* by three *kutapas*.

Nore :- The words **माषकात् कुम्भको द्रोण:** do not give any proper meaning, but on the contrary have a missing link. S.B. Dixit quotes Bhattotpala **चतुर्भि: आढकै द्रोण:** and Bhaaskaraachaarya has also said that 4 aadhakaas are equal to one drona. S.B. Dixit has further found, from YVJ. 24, that when 3 kutapas of water is removed from drona and the remainder is allowed to pass through a water clock, it takes time equal to one naadikaa.

RVJ. - 18

When the moon moves through one nakshatra, it takes seven (kalaas) more than a day and when the Sun moves through a nakshatra it takes 13 $\frac{5}{9}$ days. (The time required to pronounce one syllable is called "akshara" and five aksharas make one "kaashathaa".)

RVJ. - 19

If we break the (chain of) nakshtras, (a nakshatra) before Shravishthaa and repeat (javaadi) multiplications, we observe a ritushesha in lunar nakshatra at the intervals of six solar months.

RVJ. - 20

Make correction for extending the parvan-portion to (avoid) the error of doubling tithis at the point of the circle where the Sun becomes steady (on the day of solstice).

RVJ. - 21

Multiply the total number of nakshatras travelled by the moon in a given number of parvans by seven; you get the difference of time in kallas between the total number of nakshatras and the number of days that have passed. Know that these kalaas obtained by transformation are called Bhaadaana Kalaas.

RVJ. - 22

The length of a given day (excluding night) is equal to the number of days that have lapsed from the beginning of the northward course of the Sun, or the number of days which are required to complete the southward course, multiplied by 2 and divided by 61 plus 12 (muhoortaas).

Explanation : A day consists of 30 muhoortaas. The night in Vedaanga location was of 18 muhoortaas on the day of winter solstice; the day was 12 muhoortaas long. (See verse 7). The year roughly consists of 366 days; therefore after a lapse of a half-year i.e. 183 days, the lengths of days and nights are in reverse position. The average rate of change of the length of the day was therefore 6/183 = 2/61 muhoortas per day. The minimum length of the day was 12 muhoortas.

Example : Find out the length of the 13th day after winter-solstice.

Length of the day = 12 + 13 x (2/61) muhoortas
= 12 + 26/61 muhoortas

RVJ. - 23

"For each of those (Raashi) parvans (as obtained from RVJ. 4) we have half a portion of tithi. Note that its sum is a ritushesh along with given number of parvans".

RVJ. - 24

With these aims and means, by a process of repetitions they derive the unknown fraction of raashi (adhika maasa) from the known portion of the raashi. (for preparing a calendar of a given year as well as for the next year)

RVJ. - 25

Deities : The presiding deities of the 27 nakshatras in serial order are - Agni, Prajaapati, Soama, Rudra, Aditi, Brihaspati, Sarpa, Pitris, Bhaga, Aryamaa,

RVJ. - 26

Savitaa, Tvashtaa, Vaayu, Indraagnee, Mitra, Indra, Nirriti, Aapa, Vishvedevaas,

RVJ. - 27

Vishnu, Vasu, Varuna, Ajaikapaat, Ahirbudhnya, Pooshaa, Ashvini and Yama.

RVJ. - 28

These are the deities of the nakshatras. Remember the name of the deity which presides over the 'birth-nakshatra' of the person on whose behalf a saçrifice (or a religious rite) is to be performed, while making a sankalpa (or resolution) to begin a religious ceremony.*Note :* A birth-nakshatra means the nakshatra position of the moon at the time of the birth of a person.

RVJ. - 29

This is what sage Lagadha spoke about the lunar months years, muhoortas, the risings, the parvans (syzygies), the days, the seasons, the ayanas (i.e. both the courses of the Sun) consisting of solar months.

RVJ. - 30

There are three types of motions of the Sun and the Moon in the heaven (लोक) known to the common people (लोक). There are three types of motions of the Sun and the Moon (mathematically) analysed by the learned people.

RVJ. - 31

Note : The rule enunciated in this verse is meant for calculating the number of parvans that have passed from the beginning of the yuga if a serial number of vishuvan is known. It also gives the tithi of the vishuvan.

"Double the ordinal number of the equinox, subtract one from the product and multiply by six. What we obtain is (total) number of solar parvans (elapsed from the begining of the yuga). Thereafter it would become a tithi (by methods given in RVJ. 4 and RVJ. 23).

RVJ. - 32

The calendar of (19-year yuga) informs us that the fifth sub-yuga begins in bright wing of the month of Maagh and end with the end of dark wing of the month of pausha.

RVJ. - 33

"(i) Triteeyaa (third tithi of bright fortnight) (ii) Navamee (nineth of bright fortnight) (iii) Paurnima (full moon-day) (iv) Shashthi (sixth of dark fortnight) (v) Dvadashee (twelth of dark fortnight) are the limits of tithis for classifying the year according to vernal equinox on which the solar year begins"

Note : This verse in similiar to RVJ. 8

RVJ. - 34

On the Krishna chaturdashee day (i.e. 29th tithi of a lunation) when the moon is found just above the rising Sun (**उपैति**), then as the day dawns, presume that it is with (उपवसत:) the Sun (indicating a new-moon day). The year (thereafter) begins (on the next day) with shukla paksha, with the Sun and the Moon in Shravishthaa (nakshatra).

Note : At this point of time, solar bhaamshas and the kasthaas in lunar kalaas are presumed to be zero. There is an implied mandate in the verse to observe the moon on Krishna chaturdashee just before the next day dawns for next cycle of 19-year yuga to begin, if this astronomical event occurs on the day of winter solstice. This assures the removal of one day's difference, which may occur at the end of 76 years (i.e. four 19-year cycles). The yuga in Rig Jyotisha begins 15 tithis hereafter on a full-moon day. The Sun used to be at winter-solstice on such Paurnimaa (see chapter on antiquity).

RVJ. - 35

Like the crest on the head of a peacock or a jewel on the hood of a snake, this scientific composition of Jyotisha (Vedic astronomy) occupies the position at the top of all (six) annexures of *Vedas*.

RVJ. - 36

The Vedas are revealed (to the sages) for the purpose of performing sacrifices. They are to be performed according to a pre-determined time-table. It is the knowledge of these scientific rules of time which a sacrificer must possess.

* * *

PART - IV

CHAPTER - 12

Yajus-Jyotisham-Text

(याजुष ज्योतिषम्)

श्री गणेशाय नमः । हरीः ॐ ।।

अथ याजुषज्योतिषं प्रारभ्यते।
पञ्चसंवत्सरमयं युगाध्यक्षं प्रजापतिम्।
दिनर्त्वयनमासाङ्गं प्रणम्य शिरसा शुचिः ।।१।।
ज्योतिषामयनं पुण्यं प्रवक्ष्याम्यनुपूर्वशः।
संमतं ब्राह्मणेन्द्राणां यज्ञकालार्थसिद्धये ।।२।।
वेदा हि यज्ञार्थमभिप्रवृत्ताः कालानुपूर्वा विहिताश्च यज्ञाः।
तस्मादिदं कालविधानशास्त्रं यो ज्योतिषं वेद स वेद यज्ञम् ।।३।।
यथा शिखा मयूराणां नागानां मणयो यथा।
तद्वद् वेदाङ्गशास्त्राणां गणितं मूर्धनि स्थितम् ।।४।।
माघशुक्लप्रपन्नस्य पौषकृष्णसमापिनः।
युगस्य पञ्चवर्षस्य कालज्ञानं प्रचक्षते ।।५।।

स्वराक्रमेते सोमार्कौ यदा साकं सवासवौ।
स्यात् तदादि युगं माघस्तपः शुक्लोऽयनं ह्युदक् ।।६।।
प्रपद्येते श्रविष्ठादौ सूर्याचन्द्रमसावुदक्।
सार्पार्धे दक्षिणार्कस्तु माघश्रावणयोः सदा ।।७।।
घर्मवृद्धिरपां प्रस्थः क्षपाह्रास उदग्गतौ।
दक्षिणे तौ विपर्यस्तौ षणमुहूर्त्ययनेन तु ।।८।।
प्रथमं सप्तमं चाहुरयनाद्यं त्रयोदशम्।
चतुर्थं दशमं चैव द्वियुग्माद्यं बहुलेऽप्यृतौ ।।९।।
वसुत्वष्टा भवोऽजश्च मित्रः सर्पोऽश्विनौ जलम्।
धाता कश्चायनाद्याः स्युरर्धपञ्चमभरस्त्वृतुः ।।१०।।

एकान्तरेऽह्नि मासे च पूर्वान् कृत्वादिरुत्तरः।
अर्धयोः पञ्चपर्वाणां मृदू पञ्चदशाष्टमौ ।।११।।
दुहेयं पर्व चेत् पादे पादस्त्रिंशत्तु सैकिका।
भागात्मनाऽवपृज्यांशां निर्दिशेंशोधिको यदि ।।१२।।
निरेंक द्वादशाभ्यस्तं द्विगुणं गतसंयुतम्।
षष्ट्या षष्ट्या युतं द्वाभ्यां पर्वणां राशिरुच्यते ।।१३।।
स्युः पादोऽर्धं त्रिपाद्यायास्तिद्व्येकेऽह्नः कृते स्थितिम्।
साम्येनेन्दोः स्तृणोऽन्येषु पर्वकाः पञ्चसंमिताः ।।१४।।
भांशाः स्युरष्टकाः कार्याः पक्षा द्वादशकोद्गताः।
एकादशगुणश्चोनः शुक्लेऽर्धं चैन्दवा यदि ।।१५।।

नवकैरुद्गतोंऽशः स्यादूनः सप्तगुणो भवेत्।
आवापस्त्वयुजेऽर्धं स्यात्पौलस्तयेऽस्तंगतेऽपरम् ।।१६।।
जावाद्यंशैः समं विद्यात् पूर्वार्धे पर्वसूत्तराः।
भादानं स्याच्चतुर्दश्यां द्विभागेभ्योऽधिको यदि ।।१७।।
जौ द्रा गः खे श्वेऽही रो शा
चि (न्) मूषण्यः सू मा धा नः।
रे मृ घा स्वा ऽपो ऽजः कृ
ष्य ह ज्ये ष्ठा इत्यृक्षा लिङ्गैः ।।१८।।
कार्या भांशाष्टकस्थाने कला एकान्नविंशतिः।
ऊनस्थाने द्विसप्ततिमुद्वपेद् युक्तसंभवे ।।१९।।
तिथिमेकादशाभ्यस्तां पर्वभांशसमन्विताम्।।
विभज्य भसमूहेन तिथिनक्षत्रमादिशेत् ।।२०।।

याः पर्वभादानकलास्तासु सप्तगुणां तिथिम्।
उक्तास्तासां विजानीयात् तिथिभादानिकाः कलाः ।।२१।।
अतीतपर्वभागेभ्यः शोधयेद् द्विगुणां तिथिम्।
तेषु मण्डलभागेषु तिथिनिष्ठां गतो रविः ।।२२।।
विषुवन्तं द्विरभ्यस्तं रूपोनं षड्गुणीकृतम्।
पक्षा यदर्धं पक्षाणां तिथिः स विषुवान् स्मृतः ।।२३।।

पलानि पञ्चाशदपां धृतानि तदाढकं द्रोणमतः प्रमेयम्।
त्रिभिर्विहीनं कुडवैस्तु कार्यं तन्नाडिकायास्तु भवेत्प्रमाणम् ।।२४।।
एकादशभिरभ्यस्य पर्वाणि नवभिस्तिथिम्।
युगलब्धं सपर्व स्याद् वर्तमानार्कभक्रमात् ।।२५।।

सूर्यर्क्षभागान्नवभिर्विभज्य शेषं द्विरभ्यस्य दिनोपभुक्तिः।।
तिथियुक्ता भुक्तिदिनेषु कालो योगं दिनैकादशकेन तद् भम् ।।२६।।
त्रियंशो भशेषो दिवसांशभागश् चतुर्दशश्चाप्यपनीयभिन्नम्।
भार्धे ऽधिके चापि गते परोंऽशो द्वावुत्तमे तन्नवकैरवेद्यम् ।।२७।।
त्रिंशत्यह्नां सषट्षष्टिरब्दः षट् चर्तवोऽयने।
मासा द्वादश सूर्याः स्युरेतत् पञ्चगुणं युगम् ।।२८।।
उदया वासवस्य स्युर्दिनराशिः स्वपञ्चकः।
ऋषेर्द्विषष्टिहीनं स्याद्विंशत्या चैकया स्तृणाम् ।।२९।।
पञ्चत्रिंशं शतं पौष्णमेकोनमयानान्यृषेः।
पर्वणां स्योच्चतुष्पादी काष्ठानां चैव ताः कलाः ।।३०।।

सावनेन्दुस्त्रिमासानां षष्टिश्चैका द्विसप्तिका।
द्वित्रिंशतम् सावनस्यार्धः सूर्यः स्तृणां स पर्ययः ।।३१।।
अग्निः प्रजापतिः सोमो रुद्रोऽदितिर्बृहस्पतिः।
सर्पाश्च पितरश्चैव भगश्चैवाऽर्यमाऽपि च ।।३२।।
सविता त्वष्टाऽथ वायुश्चेन्द्राग्नी मित्र एव च।
इन्द्रो निर्ऋतिरापो वै विश्वेदेवास्तथैव च ।।३३।।
विष्णुर्वसवो वरुणोऽज एकपात् तथैव च।
अहिर्बुध्न्यस्तथा पूषा अश्विनौ यम एव च ।।३४।।
नक्षत्रदेवता ह्योता एताभिर्यज्ञकर्मणि।
यजमानस्य शास्त्रज्ञैर्नाम नक्षत्रजं स्मृतम् ।।३५।।

उग्राण्यार्द्रा च चित्रा च विशाखा श्रवणाऽश्वयुक्।
क्रूराणि तु मघा स्वातिर्ज्येष्ठा मूलं यमस्य यत् ।।३६।।
द्व्यूनं द्विषष्टिभागेन हेयं सौर्यात् सपार्वणम्।
यत्कृतावुपयुज्येते मध्येऽन्तं चाधिमासकौ ।।३७।।
कला दश सविंशा स्याद् द्वे मुहूर्तस्य नाडिके।
द्वित्रिंशत् तत्कलानां तु षट्छती त्र्यधिका भवेत् ।।३८।।
ससप्तकं भयुक् सोमः सूर्यो द्यूनि त्रयोदश।
उत्तमानि तु पञ्चाह्नः काष्ठा पञ्चाक्षरा भवेत् ।।३९।।
यदुत्तरस्यायनतो गतं स्याच् छेषं तथा दक्षिणतोऽयनस्य।
तदेव षष्ट्या द्विगुणं द्विभक्तं सद्वादशं स्याद् दिवसप्रमाणम् ।।४०।।

यदर्धं दिनभागानां सदा पर्वणि पर्वणि।
ऋतुशेषं तु तद् विद्यात् संख्याय सह पर्वणाम् ।।४१।।
इत्युपायसमुद्देशो भूयोऽप्यह्नः प्रकल्पयेत्।
ज्ञेयराशिगतान् व्यस्तान् विभजेज्ज्ञानराशिना ।।४२।।
सोमसूर्यस्त्रिचरितं विद्वान् वेदविदश्नुते।
सोमसूर्यस्त्रिचरितं लोकं लोके च संततिं
लोकं लोके च संततिम् ।।४३।।

इति याजुषज्योतिषं समाप्तम् ।

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CHAPTER - 13

Yajus - Jyotisham

(How to use)

We shall now turn to the Yajus recension of Vedaanga Jyotisha. Verses 28, 29, 30 and 31 inform us that the author of Yajus Jyotisha had in his mind elements of a 5-year yuga when he wrote these verses. Verse 31 reads as under :

सावनेन्दुस्तृमासानां षष्टिः सैका द्विसप्तिका।
द्युत्रिंशत् सावनः सार्धः सूर्यः स्तृणां सपर्ययः ।।YVJ 31

"(In a Yuga) there are 61 Saavana months, 62 lunations and 67 sidereal months i.e. naakshatra maasas; 30 days make one Saavana- month and $30^1/2$ days make one solar month. One revolution (of the moon) in stars (स्तृणां) is called a *naakashatra maasa."* This verse along with verse 4, tells us that after $2^1/2$ solar years we have one adhika maasa and in a yuga of five years we have two adhika maasas. Morever from YVJ6 we get that every quinquinial cycle in Yajus - text began on new moon day. It shall not therefore be possible for us to find out any internal evidence in the Yajus text to show that the Yajus cycle was reasonably accurate, so that it could have been used as it is, at least for a century.

On this subject, scholars have said that there might be some practice or custom observed by the Vedic priests to readjust the luni-solar cycle. Krishnashastri Godbole thought that probably one adhika maasa was dropped at the end of 40 years. Dixit observed that there should have been a practice to count 35 adhika massas in 95 years instead of 38 adhika maasas. Kuppanna Sastri guessed that there must have been a practice to drop one intercalary month at the end of six yugas and subsequently one at the end of seven yugas. This means two intercalary months might have been dropped in 65 years. When we think of any such practice, which is not included in the text itself, we have to investigate (i) some other literature of the same age, which may help us to draw a proper conclusion. External aid is one of the acknowledged modes of interpretation. (ii) It is also necessary that the conclusion which we draw about any such custom or practice must be reasonable. (iii) If we try to implement such a practice along with the Yajus text, it should not show much deviation from the actual position of the Sun and the Moon in the sky. If we follow these cannons of interpretation, the solution emerges.

Readers should imagine that we start with one such Yajus yuga on a winter-solstice, commencing from the 22nd of December with the first day of a lunation i.e. bright 1st day (Shukla pratipadaa). We have now before us verse 9 (= RVJ 8) which gives us the tithis (lunar dates) of subsequent winter solstice days in a serial order. They are bright 7th, bright 13th, dark 4th and dark 10th. We also know that the actual solar year consists of 371 tithis, while the Yajus-year consists of 372 tithis. There is a difference of 1 tithi. A tithi being practically equal to a day, within 16 years, there will be a difference of 16 days. According to our calculations, a winter solstice would appear on 6th January, while it had actually occured on 22nd December. The Sun moves one nakshatra in 13 + 7/9 tithis. We will therefore wrongly presume that on 6th January the Sun is in its original place of nakshatra, where it was at the beginning of the yuga. It would be found to have advanced by one nakshatra. At the end of 28 years the calculated positions of the moon will also differ very much from the actual one. Under these circumstances, what must have been the practice followed by the Vedic priests?

Dr. Daftari, in his lectures delivered in Nagpur University in 1940 (and subsequently published in 1942) pointed out a verse from the Mahaabhaarata which would help us in finding out the practice in correcting the calendar occasionally.

क्षयं संवत्सराणां च मासानां च क्षयं तथा । शान्तिपर्व, ch. 301

'(By way of leap) drop years as well as months.'

Though Dr. Daftari referred to this verse, he came to the same conclusion that there was a practice of dropping one intercalary month each at the end of the 6th and the 7th yugas alternately.

In this connection there are very important verses in the *Vaajasaneyi Samhitaa* and the *Taittireeya Braahmana.* They are cited by Dixit in his

Bhaaratiya Jyotisha Sastra in its first chapter. In one such verse cited from Tait. Bra. 30-10-4, we have six names of lunar years.

संवत्सरोसि परिवत्सरोसि ।
इदावत्सरोसि इदुवत्सरोसि इद्वत्सरोसि वत्सरोसि ।। तै. ब्रा. ३-११-४

(i) Samvatsara (ii) Parivatsara (iii) Idaavatsara (iv) Iduvatsara (v) Idvatsara (vi) Vatsara. Dixit further adds that Maadhavaacharya interprets the words Iduvatsara in this series as Anuvatsara. But we must know the meaning of the word *vatsara,* the sixth type of year. We get the answer, when we try to interpret Yajus cycle. With the aid of these two verses (i.e. the verses in the Mahaabhaarata and Taittireeya Brahmana), we can now explain the Yajus cycle.

.Let us again start with our astronomical cycle on winter solstice on the Shukla pratipadaa. At the end of five years, our calculated winter solstice will advance five tithis more than the real. Why not have the sixth year shorter than the usual year? If in the sixth year of the yuga, we reckon only 360 days (366 tithis) the cycle would be readjusted. The total number of tithis in a group of such six years would be (372 x 5 + 366 =) 2226. The average would again be 371 tithis per year. It is well known that in ancient Indian astronomy, a year consisting of 360 days was called a Saavana year. In the 31 verse (cited above) a Saavana month is defined. It consists of 30 days. In the Rik recension we do not find any reference of Saavana month or Saavana year. The reason is obvious that such a year was not necessary in the Rik calendar. Let us verify the results by treating a Saavana year as *vatsara* as part of the cycle as enlisted in Tait Brh. 3-10-4. We have prepared Table-7 by inserting Saavana year as the sixth year. Readers should note that there is a difference between Rig ayana (Rik Semester) and Yajus ayana (Yajus semester). Yajus ayanas are longer than Rig ayanas by a half-tithi. They begin on different tithis. Let us call a Yajus ayana which begins near winter solstice as vernal ayana **(वसन्त अयन)** and the one that begins near summer solstice as autumn ayana **(शरद् अयनम्)** of the year.

From Table 7 we find that there is an addition of one tithi in the beginning of the subsequent year with respect to the position of the winter solstice. (see column 5). The date of the beginning of the Yajus solar year advances by 12 tithis per year (See column 6). Thus in place of Shukla

TABLE NO. 7

Sr. No.	Name of the year	Total days	Total Tithis	Speciality	Solar day at the beginning of the Semester	Tithi at the beginning of the Semester	Nakshatra at the beginning of the Semester
	1	2	3	4	5	6	7
1.	Samvatsara	366	372		Uttaraayana	Maagha Shukla 1	Shravishthaa
2.	Parivatsara	366	372		2nd day	Maagha Shukla 13	Punarvasu
3.	Idaavatsara	366	372	Additional month $(2^{1}/_{2})$	3rd day	Maagha vadya 10	Jyeshthaa
4.	Anuvatsara	366	372		4th day	Maagha vadya 7	Bharanee
5.	Idvatsara	366	372	Additional month $(2^{1}/_{2})$	5th day	Maa. vad. 4	Hasta
6.	Sammidaa (संमिदा)	360	366	Saavana year	6th day	Maa. shu. 1	Shatataarakaa
7.	Anuvatsara	366	372		Uttaraayana	Maa. shu. 7	Bharanee
8.	Itvatsara	366	372	Additional month (3)	2nd day	Maa. vad. 4	Hasta
9.	Samvatsara	366	372		3rd day	Maa. shu. 1	Shatataarakaa
10.	Parivatsara	366	372		4th day	Maa. shu. 13	Pushya

Table No. 7 Contd......

	1	2	3	4	5	6	7
11.	Idaavatsara	366	372	Additional month ($2^1/_2$)	5th day	Maa. vad. 10	Moola
12.	Anusama (अनुसम)	360	366	Saavana year	6th day	Maa. shu. 7	Krttikaa
13.	Parivatsara	366	372		Uttaraayana	Maa. shu. 13	Pushya
14.	Idaavatsara	366	372	Additional month (3)	2nd day	Maa. vad. 10	Moola
15.	Anuvatsara	366	372		3rd day	Maa. shu. 7	Krttikaa
16.	Idvatsara	366	372	Additional month ($2^1/_2$)	4th day	Maa. vad. 4	Chitraa
17.	Samvatsara	366	372		5th day	Maa. shu. 1	Poo' Bhaa
18.	Paryanu (पर्यनु)	366	372	Saavana year	6th day	Maa. shu. 13	Aashleshaa
19.	Idvatsara	366	372	Additional month (3)	Uttaraayana	Maa.vad. 4	Chitraa
20.	New Yuga			Samvatsar	Uttaraayana	Maa. shu. 1	Shravishthaa

first tithi in the subsequent year, we get Shukla 13th tithi. But in the sixth year we have only 366 tithis. The year therefore advances only by 6 tithis. As a result, the 7th year begins with Shukla seventh. The name of the year is given according to the tithi at its beginning (see chart I). The seventh year is therefore called Anuvatsara. It is worthwhile to note that the sixth year has a beginning like samvatsara (Shukla First) and it ends like Idaavatsara on Shukla sixth. For facility of narration. We have named the year as Sammidaa (**संमिदा**) .

The effect of inserting a saavana year as the sixth year is that we have dropped parivatsara and idaavatsara after the sixth year which would have been the seventh and the eighth year in the normal course. The name Idaavatsara indicates that there should be a adhika maasa in the middle of the year i.e. before summer solstice we have dropped an adhika maasa. In this sense we have dropped two years and one month between the sixth and seventh years in the series.

We have three Saavana years in the Series of years give in Table 7. They are at serial No. 6, 12 ad 18 Sammidaa (**संमिदा**) , Anusama (**अनुसम**) and Paryanu (**पर्यनु**) respectively. If we presume that we have dropped two 2 years, each time following these three saavana years, the total number of years which we have dropped would amount to six. Let us now imagine a series of 25 years (five batches of five year each) and then subtract six years as stated earlier. We are left with a yuga of 19 years.

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CHAPTER 14

Concurrent Adhika Maasa

It will be interesting to compare the intervals at which adhik maasas appear in Yajus cycle with those in the Rik cycle. Table 7 gives Yajus cycle, while Table 2 gives a Rik cycle. In Yajus cycle the Adhika maasas apear at the intervals of $2^{1}/2$, $2^{1}/2$, 3, $2^{1}/2$, 3, $2^{1}/2$, 3 years while they appear at the intervals of 3, $2^{1}/2$, 3, $2^{1}/2$, 3, $2^{1}/2$, $2^{1}/2$, years in the Rik cycle.

We have prepared Table 7 in search and flow of a cognent explanation of the internal and external evidence of the Yajus cycle. It can be rearranged without violating the rules, so that the adhika maasas take concurrent place in both the types of yugas. Table 8 shows readjusted Yajus yuga. We have not disturbed the cycle order of years while preparing Table 8. We have only given first place to sixth year in Table 7 while preparing the Table 8.

The first year in Table 8 is Saavana year which is a short year and therefore the next year begins with a tithi which comes earlier before the winter solstice. All the years in the Yajus cycle must therefore begin on or before the winter solstice. Their beginning are therefore indicated by (–) sign in column 5 of table 8.

New meaning in the context of Yajus cycle.

Two verses Rik 20 and 24 are also included in Yajus Jyotisha. They are Yajus verses 22 and 42.

अतीतपर्वभागेषु शोधयेद् द्विगुणां तिथिम्।
तेषु मण्डलभागेषु तिथिनिष्ठां गतो रविः ।।YVJ 22
इत्युपायसमुद्देशो भूयोप्येन् प्रकल्पयेत्।
ज्ञेयराशिं गताभ्यस्तान् विभजेद् ज्ञानराशिषु ।।YVJ 42

In the new context, Yajus verse 22 can be explained by the following figure.

TABLE NO. 8

Sr. No.	Name of the year	Total days	Total Tithis	Speciality	Solar day at the beginning of the Semester	Tithi at the beginning of the Semester	Nakshatra at the beginning of the Semester
	1	2	3	4	5	6	7
1.	Sammidaa (संमिदा)	360	366	Saavana year	Uttaraayana	Maagha Shukla 1	Dhanishthaa
2.	Anuvatsara	366	372		– 5 days	Maagha Shukla 7	Ashvini
3.	Idvatsara				– 4 days	Maagha vadya 4	Utt' Phalgunee
4.	Samvatsara				– 3 days	Maa. Sh. 1	Dhanishthaa
5.	Parivatsara				– 2 days	Maa. Sh. 13	Aardraa
6.	Idaavatsara				– 1 day	Maa. Vad. 10	Anuraadhaa
7.	Anusama (अनुसम)	360	366		Uttaraayana	Maa. Sh. 7	Ashvini
8.	Parivatsara				– 5 days	Maa. Sh. 13	Aardraa
9.	Idaavatsara				– 4 days	Maa. Vad. 10	Anuradhaa
10.	Anuvatsara				– 3 days	Maa. Sh. 7	Ashvini

Table No. 8 Contd......

	1	2	3	4	5	6	7
11.	Idvatsara				– 2 days	Maa. Vad. 4	Utt' Phal.
12.	Samvatsara				– 1 day	Maa. Sh. 1	Dhanishthaa
13.	Paryanu (पर्यनु)	360	366		Uttaraayana	Maa. Sh. 13	Aardraa
14.	Idvatsara				– 5 days	Maa. Vad. 4	Utt' Phaal.
15.	Samvatsara				– 4 days	Maa. Sh. 1	Dhanishthaa
16.	Parivatsara				– 3 days	Maa. Sh. 13	Aardraa
17.	Idaavatsara				– 2 days	Maa. Vad. 10	Anuraadha
18.	Anuvatsara				– 1 day	Maa. Sh. 7	Ashvinee
19.	Idvatsara				Uttaraayana	Maa. Vad. 4	Utt' Phaal.
20.	New Yuga				Uttaraayana	Maa. Sh. 1	Dhanishthaa

7th W.S. 13th

We have taken for example the 10th year from Table 7. We have Maagha Shukla seventh tithi before winter solstice and Maagha Shukla 13th tithi after winter solstice. Verse nine which begins with **प्रथम सप्तमं चाहुरयनाद्यं** (First, seventh, thirteenth are the beginnings of ayanas) gives as a fixed set of tithis from which we have to choose one proper tithi near winter solstice (**तिथिनिष्ठां गतः**). We therefore exclude the portion from the seventh tithi onwards from the previous year. The author of Vedaanga calls this portion "excess portion of the parvan". When we approached the end ofthe seventh year in Table 8, we find 366th tithi of the year is Shukla 12th, the next tithi Shukla 13th is on the day of winter solstice. A normal year should have started on Vadya 4th. When we start with the eightth year, we have to make a choice between Shukla 15th and Vadya 4th. Verse 22 asks us to sever **अतीतपर्वभाग** i.e. the excess portion of the parvan beyond winter solstice. We therefore choose Shukla 13th as the beginning of the 8th year even at the cost of making the seventh year small by 6 tithis. Seventh year thus becomes a saavana year.

42nd verse - The interval of time between the end of a lunar year and the winter solstice was called *raushi-vibhaaga* (i.e. fraction of an adhika maasa), because this portion gradually increases in succeeding years and gets converted into an adhika maasa. In verse 42 (**इत्युपायसमुद्देशो**) we get a general direction to repeat the aforementioned process about dividing the ritushesha to determine the ends and beginning of ayanas.

Aforementioned modification in Yajus cycle can be enunciated in the following rule -

"In Yajus cycle of Vedaanga the two semesters in a year used to begin on the first day of the shalahas in which the winter solstice and the summer solstice occurred".

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CHAPTER 15

Nakshatra of the Yajusha Ayanas

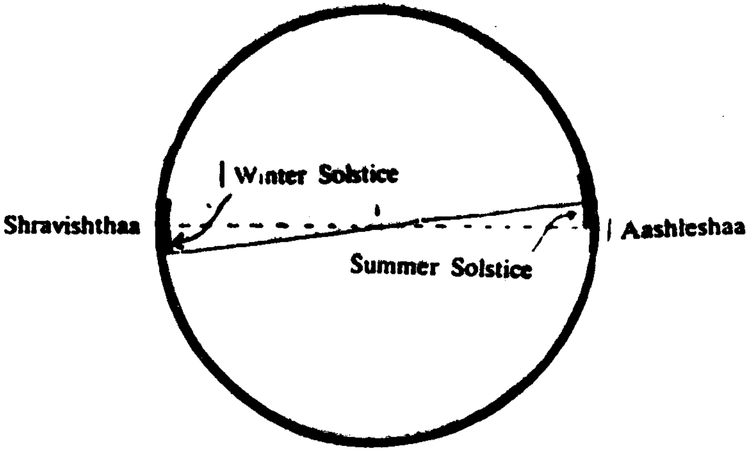
Knowledge of the beginnings of lunar nakshatras at the beginning of each Yajus ayana was also important for the Yajus priest. There is no verse in the Yajus text equivalent to RVJ. 19 which begins with श्रविष्ठाभ्यां गुणाभ्यस्तान्; because, for Yajus priest his verse 10 वसुस्त्वष्टा was sufficient to find out the lunar nakshatras at the beginning of Yajus ayanas.

Dixit has reproduced in his history of Indian astronomy Somaakara's 16 verses on this point. (S.B. Dixit Vol.1 page 71). He has prepared a small chart from Somaakara's description, which is given in Chart III. Most of the scholars so far relied on this chart for finding out the tithis

CHART NO. III

Sr. No.	Name of the year	Winter Solstice		Summer Solstice	
		Tithi	**Lunar Nakshatra**	**Tithi**	**Lunar Nakshatra**
1.	Samvatsara	Maagha Sh. 1	Dhanishthaa	Shraavana Sh. 7	Chitraa
2.	Parivatsara	-"- Sh. 13	Aardraa	-"- Vad. 4	Poorvaa Bhaad
3.	Idaavatsara	-"- Vad. 10	Anuraadha	-"- Sh. 1	Aashleshaa
4.	Anuvatsara	-"- Sh. 7	Ashvinee	-"- Sh. 13	Poorvaa-shaadhaa
5.	Idvatsara	-"- Vad. 4	Utaraa Phaalgunee	-"- Vad. 10	Rohinee

Figure 3



and the nakshatras of winter and summer solstices in a system of 5 year yugas. According to us, though the tithis and the nakshatras given in the chart do not show the actual position of winter and summer solstices, they indicate the beginnings of Yajus ayanas in the years, whose names are given in the chart. The basis of this chart is Yajus verses 9 and 10 i.e. प्रथमं सप्तमं चाहुः and वसुस्त्वष्टा. Only the names of the lunar years samvatsara, parivatsara etc. are provided by Somaakara. In this respect he has himself quoted Garga.

Let us take an example of Idaavatsara. From Chart III, we know that its vernal ayana (वसन्तायनम्) must begin on the 10th of Vadya when the moon is in Anuraadhaa nakshatra. Let us now refer to Table 8. In this table sixth, nineth, and seventeenth years are Idaavatsaras they respectively begin on first, fourth, and second days before the winter solstice. Thus a Solar Shalaha (six days) in which winter solstices is the last day, prescribes the limit of the beginnings of the ayana. Let us call this Shalaha as basic Shalaha. It is a mathematical requirement that the Sun must have remained in the first half of Shravishthaa during its journey in the basic shalaha (see Figure 3). When the Yajus civilisation witnessed the tithis and nakshatras given in Chart III, the moon was required to be in a particular range of angular distance from Shravishthaa corresponding to the name of the year given in Chart III.

The Automnal Ayana

The summer solstice is at a distance of $13^{1}/_{2}$ nakshatras from winter solstice. With similar reasoning as in the preceeding paragraph, we find that the point of summer solstice was at the eastern end of aashleshaa.

When we consider the positions of the beginnings of both the Yajus ayanas, we have to conclude that the point of Winter Soltice was the centre of Shravishthaa during the Yajus Jyotisha period. Autumn Ayana therefore began when the Sun was in the latter half portion of Aashleshaa.

The Saavana years

Saavana years consist of 366 tithis i.e. 360 days. We do not have separate rules to fix the beginnings of their ayanas. Chart III with Yajus verses 9, 10, 22 and 42 are our rules to fix the beginnings of the ayanas. For example let us take the first year in Table 8. In being a samvatsara, its vernal semester should begin on Maagha Shukla first and autumn semester should begin on Maagha Shukla seventh. Eventually the vernal semester would consist of 186 tithis, while the autumn semester would consist of 180 tithis. Thus for practical purposes the first year in Table 1 is Samvatsara, seventh year is anuvatsara and 13th year is parivatsara. The only difference is from total 372 tithis, their last Shalaha is removed. We have thus five samvatsaras in the Yajus cycle also. Yajus text therefore begins with the words *Pancha-samvatsara- mayam yugaadhyaksham.*

Advantages

No doubt there is a little loss of accuracy in the Yajus cycle, because its basic position has widened into a Shalaha from a point in Shravishthaa; but the particulars of the beginnings (tithis & nakshtras) of its ayanas have become easier to remember. Verses nine and 10 give all the particulars. It is usual experience in the practical applications of science, that the thumb rule is always easier to remember. But in the majority of cases, thumb rules are applied with the calculated loss of accuracy. Yet the loss of accuracy is much less than that was conceived by the scholars so far.

Let us view the Yajus cycle from a different angle. From Table 8 we find that the years at Sr. Nos. 1, 7, 13 and 19 form cross lines dividing the chain in three sections. Out of these four years, the first three are Saavana years, and the 19th year Idvatsara is the last year. We can therefore call them as cross lines. In between these cross lines, we have three groups of five solar years. In every such group we have 2 adhika maasas. Verse 31 सावनेन्दु is applicable to all such batches of five years. For the solar positions at the end of each parvan, Dixit's tables at Appendix 3 can be used according to their names.

"Two intercalary months arise in batches of five years". From Table 8 we find that all these batches of five years do not begin with samvatsara; yet their cyclic order is maintained.

* * *

CHAPTER - 16

Balancing Provisions

The author of the Yajus-Text was aware of the fact that the observed astronomical periods of the sun and the moon differ from the periods of the year from which angular and the time units are derived i.e. those of the basic year. He has, therefore, made some balancing provisions so that his calender should accord with actual astronomical observations, without disturbing the arrangement given in Table 8 of this book.

A sidereal year consists of 365.256 days. The basic year from which we derive the definitions of the fundamental time units and angular units, as stated in Rik-text consists of 366 days. Sage Lagadha provides RVJ. 12 and 13 to reduce the length of the basic year to match it with the observed year. These verses also modify the units of the *Solar nakshatras* i.e. the angular distance and time taken by the Sun to cover 1/27th division of its yearly journey, as also of the lunar-nakshatra i.e. 1/27th of the angular distance and time taken by the moon to complete a sidereal month. A set of five years of Rik-cycle therefore consists of about 1826.25 days, (more accurately 1826.28 days) or 1855 tithis.

The basic year or the year of definitions of various angular and time units are the same for both the cycles. The schemes for inserting intercalary days & intercalary months for these two cycles are different. The lengths of their solar-nakshatra and the lunar nakshatra are, therefore, different. For proper understanding of the in their difference in these two cycles they are explained here.

1831 st day in a Yuga

Vedic sages used for smaller time units kalaas, kasthaas and aksharaas. However for convenience we will use decimal fractions. The units kalaas, and kasthaas are used wherever necessary. The Yajus cycle of five years consists 62 synodic months. Their total length is 29.5306 x 62 = 1830.8972 days, roughly 1831 days. This was the length as observed by the sages for the five year Yajus cycle. Let us see how and where this day is added in Yajus cycle. However before we proceed to knowthe adjustment of 1831st day in Yajus cycle it is necessary to know the concept of seasons in Yajus-cycle.

Seasons in Yajus cycle

If we presume 1860 tithis or 1830 days in five year cycle we have the ratio of total number tithis in a yuga with that of total number of days as 62/61. A season or ritu (ऋतु) in a Yajus-cycle comprises 61 days (366/6 days) we have therefore following verse :

एकान्तरेऽहिन मासेच पूर्वान् कृत्वादिरुत्तरा ।
अर्धयोः पंचवर्षाणां ऋतु पंचदशाष्टमौ ॥१॥

YVJ. 11 :- "Next ritu (Season) occurs after the previous one, after an alternate period of one (synodic) month and a tithi (31 x 2 = 62 tithis). Half number of ritus are covered in half cycle. He eighth ritu begins with 15th tithi." This presumably means, we have to omit a tithi at the end of a season i.e. 62nd tithi in a group. This verse is followed by RVJ. 12.

द्यु हेयं पर्व चेत् पादे पादस्त्रिशत्तु सैकिका ।
भगात्मनाप्रवृज्यांशां निर्देशोंशोऽधिको यदि ॥१२॥

YVJ. 12

This verse suggests addition of one day to a yuga to make it 1831 days. The word (द्युहेयं) means to omit or avoid a day. Tilak explains the verse in following words.

> "A day, a nycthemeron (द्यु) should be omitted, if a parvan is at (that is ends in) a pada, A pada is thirty and one (amshaas), one should indicate the excess, if any after dividing the amshaas by all the bhagaas themselves i.e. by 124".

Tilak asks us to refer to amsha-saarini (given by us in appendix 3D) for **Anuvatsaraa.** At the end of 93rd parvan the Sun is shown (in column 4) to cover 31 Bh^{o}. Tilak suggests that a day without any ordinal number of a tithi should be observed after the end of 93rd parvan, as an extra leap day so that we get 1831 days in a cycle. We suggest that YVJ. 12 is an exception to the rule given in YVJ. 11. According to YVJ. 11, we have to omit (1860-1830) 30 tithis in Yajuryuga. Kartik Vadya eighth is a tithi after 93rd parvan on which 23rd ritu in a yuga ends. The author of Yajus-text asks us not to drop this tithi i.e. to avoid this day from the rule YVJ. 11, so that the total number of omitted tithis in a yuga are 29, making the total number of days as 1831. The meaning of YVJ, 12 is therefore as follows:-

YVJ. 12 :- "A day, a nycthemeron (द्यु) should be omitted (from the application of the rule YVJ. 11) if a parvan ends at a pada. A pada is thirty and one (amshas). One should indicate the excess, if any after dividing the amshas by all the bhagaas themselves i.e. by 124".

Solar Nakshatras in Yajus text

The average Yajus year in five yar cycle thus increases from 366 days to 366.2 days (1831/5). The length of each of the 135 solar nakshatras in the yuga is expected to increase proportionately, but the author of the Yajus text locates the place of correction only at 94th parvan, in *Anuvatsaraa*. However, the purpose of YVJ. 12 (द्युहेयं—) is similar to RVJ. 12 (त्र्यंशी भशेषो ----) that is to readjust the length of a solar nakshatra. We have herein before given with Table 8 our theory of application of Yajus-text in the context of 19 year cycle, it would again be delt with at latter stage after discussing the subject of length of lunar nakshatras.

Lunar Nakshatra in Yajus text

For adjusting the lengths of lunar nakshatras as obtained from the basic year to those as actually observed, the author of the Yajus text provides YVJ. 27 (त्र्यंशीभशेषो -----), Though the words in this verse are apparantly similar to those in RVJ. 12 the purpose for its provision is different. It is a small, yet, very important change.

Let us first find out the total number of lunar nakshatras in a five year cycle with modern value of astronomical constants. We have in five years 62 lunations with their total length 29.530588 x 62 = 1830.896456 days. If we find out the sidereal periods of the moon in this span of time, they are :-

1830.896456/27.32166 = 67.01263598.

Each sidereal period of the moon consists 27 lunar nakshatras. Therefore, total number of lunar nakshatras in a Yuga are : $67.01263598 \times 27 = 1809.3418$ nakshatras. Considering the probable standard of accuracy during Vedanga period, it would be $1809\frac{1}{3}$ nakshatras or about $124/3 = 41\frac{1}{3}$ Bh° in excess of 1809 naksharas as derived from the original definition of the five year cycle. A parvan also consists of equal number of lunar Bhamshaas i.e. 1809 Bh°. we have to correct it as 1 parvan = $1809\frac{1}{3}$ lunar bhamshaas. This modification is given in YVJ. 27.

Length of Parvans

The Moon crosses 1 Bh° in about 5 kalaas, therefore 1/3 Bh° is crossed by it in 5/3 Kalaas. It we ignore 62nd and 124th parvans for correcting lunar Bhamshaas in total number of 124 parvans in a 5 year Yuga we get $\frac{5}{3} \times 122 = \frac{610}{3}$ Kalaas of increment i.e. 1/3 lunar nakshatra in a Yuga. The author of Yajus text uses the words "divasaamshbahaga" in first line of YVJ. 27 for this purpose.

The second half of the first line of verse YVJ. 27 reads "Chaturdasyaapyapaneeya Bhinnam". The words api + apaneeya bhinnam are different from the words 'pupaneet bhinnam' which are used in similar verse in Rik-text RVJ. 12. The words "apaneeya menas 'separable' "bhinnam" means "different from." Therefore apaneeyabhinnam means "different from separable". Two negatives together make one affirmative, therefore in the present context they mean "integral part". We are thus required to add 1/3 Bh° to each lunar parvan as obtained from YVJ. 15 (i.e. RVJ. 10) which begin with the words "Bhaamshasurathaka Karya" (i.e. in Table 6A, column 3 of the book). Even if we add 1 Bh° to every third parvan successively increasing the total it would suffice. If we prepare tables for lunar nakshatras in Yajus text we will require 5 tables similar to these given in Appendix 3. The author of Yajus text directs us to exclude the navaka i.e. the tithi at the end of each of the half cycle (62nd and 124th parvan) from the operation of the rule given in first line of YVJ. 27. The total number of bhaamshas added to lunar-nakshatras in the cycle are thus $40\frac{2}{3}$. The change in the number of lunar bhamshas have no consequential change in Bhaadan Kalaas becuase the total length of five year lunar "nakshatras cycle" is only equated by YVJ. 27 with the total length of five years "parvan cycle".

With this explanation the meaning of the verse YVJ. 27 can be stated as follows :-

YVJ. 27 :- Treat one third (Lunar) bhaamsha with corresponding part of the day (measured in Kalaas) as integral part of every Chaturadashi (14th tithi) in the Yuga. Exclude those Chaturdashis which we reach at the end of half of the Yuga (from such computation).

Total days in YVJ. cycle 19 years

We have Appendix 3 A-B-C-D-E which give us the particulars of parvan nakshatras and bhamshaas of these five years. If we prepare similar five tables for bhadaankalaas for these five years and substitute these years in Table 8 according to the names of these years we have a 19 year cycle converted from five year cycle. Chart III shows the tithis and nakshatras of the years. We know that every YVJ. year except Anuvatsara consists of 366 days. Anuvatsara consists one more day. In 19 years we have three Anuvatsara years and one Anusam year (See Table 8). The total number of days in 19 years should therefore be 16 x 366 + 3 x 360 + 4 = 6940 days, ultimately the length of an year in such a cycle becomes 365.263 days.

Table of Comparison (RVJ - YVJ)

Dixit gives a table of comparison of RVJ. and YVJ. verses (See Dixit, pp. 68, Vol. I). That is table 9 with few modifications. We have explained all verses of Rik-Text. We have shown that some verses in Yajus-Text which are apperantly similar in wordings to corresponding RVJ. verses with slight changes. These minor changes connote a different meaning to the said verse. Such verses are named as parallel verses and have been denoted by using the | | symbol in Table 9. Their meaning is given at relevant places. There are some pairs of verses in the two texts which give the same meaning yet their wordings are same or different. We have indicated such pair with a equal sign (=) in Table 9.

Table 9

Analysis of Rg-Jyotisa						Analysis of Yajus-Jyotisa								
R		Y	R		Y	Y		R	Y		R	Y		R
1	=	1	19		0	1	=	1	19	=	11	37		0
2		0	20	||	22	2	=	3	20		0	38	=	16
3	=	2	21	=	21	3	=	36	21	=	21	39	=	18
4	||	13	22	=	40	4	=	35	22	=	29	40	=	22
5	||	6	23	=	41	5	||	32	23	||	31	41	=	23
6	=	7	24	||	42	6	||	5	24	=	17	42	=	24
7	=	8	25	=	32	7	=	6	25		0	43	||	30
8	||	9	26	=	33	8	=	7	26		0			
9	||	10	27	=	34	9	||	8	27	||	12			
10	=	15	28	=	35	10	||	9	28		0			
11	=	19	29		0	11		0	29		0			
12	||	27	30	||	43	12		0	30		0			
13		0	31	||	23	13	||	4	31		0			
14	=	18	32	||	5	14		0	32	=	25			
15	||	17	33		0	15	=	10	33	=	26			
16	=	38	34		0	16		0	34	=	27			
17	=	24	35	–	4	17	||	15	35	=	28			
18	=	39	36	–	3	18	=	14	36		0			

PART - V

CHAPTER - 17

Miscellany

Place of composition

The geographical latitude of the place of composition of Vedaanga Jyotisha can be calculated from the lengths of the days and nights recorded in it on the day of winter-solstice. The verses RVJ. - 7 and 22, deal with this subject. RVJ. 22 reads as under :-

यदुत्तरस्यायन तोयंस्यात् शेषंतु यद्दक्षिणतोयनस्य।
तदेक पष्ट्या द्विगुणं द्विभक्तं स द्वादशं स्याद्दिवसप्रमाणम्।।२२।।

The length of each half of a solar year is about 183 days. A day consists of 30 Muhurtas. The shortest length of the day on winter solstice appears to be observed by the author as 12 Muhurtas. The author of Vedaanga presumes that the length of the day increases by simple rule of three after winter-solstice.

During the northward course of the Sun (उत्तरायण) till the day of summer solstice the length of the day would increase by 6 Muhurtas and become 18 Muhurtas. Therefore the daily increase in its length would be 6/183 Muhurtas i.e. 2/61 Muhurtas. In southern course of the Sun it would decrease at the same rate. The verse therefore means :

"The length of a given day (excluding night) is equal to the number of days that have elapsed from the begining of the northward course of the sun or the number of days which are required to complete the southern course, multiplied by 2 and divided by 61, plus 12 (Muhurtas)"

Dixit has calculated the latitude of the place of composition of Vedaanga Jyotisha from the length of the day given in RVJ. 22 as 34° 54' N. It is definite that the text was composed in India because of its special feature of reckoning intercalary months at the end of any of the two solstices. Srinagar and Taxasheela are situated at about 34° N. The northern most course of the river Indus is near 36° N. Janmejaya, the grandson of Arjuna, established a asharam at Taxasheela and is probably the place of the composition of the text.

EVOLUTION OF CALENDAR IN INDIA BEFORE RVJ

The stages of development of the science of astronomy in the Vedic period in India was cursorily reffered to in the introduction. In this chapter more detales of the type of calendar in the period immediately preceeding the date of composition of the Rik-text of Vedaanga are discussed.

It is worthy to investigate what type of luni-solar calendar was used in India before the Vedaanga Calendar was composed and which were the evolving stages of knowledge of Vedic sages before knowing 19-year luni-solar cycle.

It appears that the text Shatapatha Braahmana was composed three generations after the Mahabhaarata war. The name of King Janmejaya, the grandson of Abhimanyau, i.e. the son of Arjuna, appears in Shatapatha-Braahmana (S.B. Maadhyandin, XIII, 5, 4, 1). This is coroborated by the information given in Chap. 318 of Shanti-parva of Mahaabhaarata. It states that Shukla Yajurved and Shatapatha-Braahmana were composed by Yaajnavalkya, the nephew of Vaishampayana, the disciple of Vyaasa. This Vyaasa was uncle of Pandawas. He wrote first edition of Mahaabharta, The antiquity of Shatapatha Braahmana is known. We will get it at later stage. Let us first know what was the calendar-system used in Mahaabharata and Sathapatha Braahmana.

During Mahaabharata times there was practice of computing five-year Yuga with two intercalary months at the end of 30 lunations each. Verses 47-3-4 from Viraata-parva of Mahaabharata are usually cited for describing its calendar system. Pandavas agreed to live in forests for 12 years and thereafter to be in concealment for one year. Duryodhana expressed his doubt to Bheeshma about Arjunas coming out of concealment before the agreed date. Bheeshma gave his decision that Arjuna has not committed breach of agreement and says :

तेषां कालातिरेकेण ज्योतिषांच व्यतिक्रमात्।।
पंचमे पंचमे वर्षे द्वौ मासावुपजायतः।।
तेषामभ्याधिका मासाः पंच द्वादशच क्षपाः।।
त्रयोदशानां वर्षाणांमिति मे वर्तते मतिः।।
वि.प. ४८. ३-४

Scholars interpret the word "Kshapaa" as half tithi though its usual meaning is "night". These verses therefore mean : "Due to excess of time and deviations of the (celestial) luminaries a set of five-year gives rise to two months (so) the (stipulated period of) thirteen years of theirs (the Pandavaas) exceed by five months and twelve kshapaas (six tithis).

The aforementioned verses show that Mahaabharata sages computed their religious or civil year to consist 372 tithis. We have seen that the tropical year consist of (approximately) 371 tithis. The sages must have therefore allowed a drift between the first day the religious (or civil) year and that of the tropical year (It may be winter solstice or vernal equinox). They must have also made some arrangement to readjust the drift after a fixed period.

Shatapatha Braahmana (S.B) gives us the information about the method of readjustment, and maximum difference in number of days between first day of tropical year and the first day of the religious year. Let us call their calendar as Shatapatha Jyotisha (SPJ).

Shatapatha civilisation used a calendar mainly for performing their sacrifices. From S.B. II. 3-2 we get that they could find out the days of winter and summer solstices. From S.B. XII. 2.3.7 we know that they could also mark the two equinotical days.

The sages of Shatapatha Braahmana also computed adhik maas i.e. 13th month of their calendar (S.B. XII. 2.2).

We have evidence to show that the Shatapatha civilisation used three chains of five year Yuga in 15-years and again adjusted their calendar with tropical year. With five-year Yuga, we have to add six intercalary months in 15-years but the corresponding winter solstice occurs at the point of time when $5^1/_2$ intercalary months are added (because 11 x 15 = 165 tithis). Therefore, at the end of fifteen Solar years, Winter solstice would occur on full moon day. For next fifteen years the lunar months and the yearly sacrifices can be computed to begin at full moon.

The calendar of Daakshaayaniya yearly-sacrifices in Shatapatha Braahmana appears to be arranged on the principles given in proceeding paragraph. The religious functions and sacrifices used to remain closed in intercalary months and parvans. Let us call such parvans as **off-parvans.**

Verses XI 1.2, 10-11 read as under :

आजिं वाऽएते धावन्ति ये दर्शपूर्णमासाभ्यां
यजन्ते स वै पंचदश वर्षाणि यजेत तेषां
पंचदशानां वर्षाणां त्रीणि च शतानि
षष्टिश्च पौर्णमासाश्चामावास्याश्च
त्रीणि च वै शतानि षष्टिश्च
संवत्सरस्य रात्रयस्तहारात्रीराप्नोति ।।१०।।

Meaning : "Verily they who perform the New and Full Moon sacrifices run a race. One ought to perform it during fifteen years :- in these fifteen years there are three hundred and sixty full moons and new moons (together), and there are in a year three hundred and sixty nights. It is the nights he gains", S.P.B. 1.2-10.

अथापराणि पंचदशैव वर्षाणि यजेत। तेषां
पंचदशानां वर्षाणां त्रीणि चैव शतानि षष्टिश्च
पौर्णमासाश्चामावास्याश्च त्रीणि च वै शतानि
षष्टिश्च संवत्सरस्याहानि तदुहान्याप्नोति
तद्देव संवत्सरमाप्नोति ।।११।।

This means : "He should then offer for another fifteen years, in these fifteen years there are three hundred and sixty full moons and new moons (together) and there are in a year three hundred and sixty days; it is the days he gains and the year itself he thus gains", S.P.B. 1.2-11.

In the first term of 15-years we have 360 religious parvans and 11 **off parvans.** The sage-post compares the 360 religious parvans with 360 nights. In the second term we have 360 religious parvans comparable to 360 days (with off parvans). The poet then calls this period of 360 nights and 360 days (i.e. 30 years) as "great year" (संवत्सरमाप्नोति). Simple arithmetical calculations reveal us that those who knew the 15-year cycle with Vedic system of parvans must have known that a solar year consists 371 tithis.

There is a very usefull verse in Rigved in this respect - Rig. III - 9-9 which says :-

"Three thousand, three hundred and thirty nine (3339) divinities have worshipped AGNI : They sprinkled upon him melted butter, they have spread for him the sacred grass; and have seated him upon it as their ministrant priest. (Wilsons Trans). The same verse is repeated in Rig. X-52-6.

The figure 3339 is odd. It indicates number of Bhamshaas on the ecliptic; 3339/9 = 371 number of tithis. It follows that Rig-vedic sages also knew that a solar year comprises of 371 tithis. (It is possible that on every tithi nine priests might have offered oblations in non-stop sacrifice continued for a solar year).

A very interesting article on this subject is written by Prof. Subhash C. Kak of Louisiana State University (U.S.A.) "Astronomy in Shatapatha Braahaana" (Kak 1991). He first discusses the "Philosophy of equivalance" as pointed out by Seidenberg. Thereafter he shows that the dimensions of the alters of Agnichayana rites successively increase from $7^1/_2$ square purusha to $101^1/_2$ square purusha indicating total number of 95 altars with probable duration of 95-years of scrifices.

The knowledge of 15-years luni-solar cycle or of 95-year luni- solar cycle can only be obtained if there is a practice of observing the positions of the sun and moon on the days of solstice or on equinox at the intervals of five-years. The method of such observations may be as described in RVJ. 34. Shatapatha Braahmana missed to note the 19-year cycle because they did not observe the sky every year.

Pancha siddhaantikaa

Shatapatha Jyotisha (SPJ) throws light in the understanding of two Sidhaantas in Panchasidhaantikaa of Varaahamihira.

The first line of the first verse of Pitamaha Sidhaanta apparently appears self contradictory.

"According to the teaching of Pitaamaha, five years constitute a yuga of the sun and the moon. The adhimasas occur after thirty months and an omitted lunar day (avam) once in sixty three days"

(trans by S.B. Dixit
Vol. II Page 3).

In five year-yuga, omitted tithis occur at the rate of one tithi per 61 days. They occur once in 63 days either in 19-year cycle or in 15-year cycle of Shatapatha calendar. The 15-year cycle is subdivided in 3 groups of five year cycles. The five year yuga is not necessarily linked with winter-solstice or any of the four fixed days of tropical year. With this explaination we find that there is no contradiction in the above referred line of Pitaamaha Sidhaanta.

Pancha Sidhaantika gives another Sidhaantha known as Romaka Sidhanta. The 15th verse of the first chapter of Panchasidhaantika reads as under :

"Romaka yuga consisted of 2850 years. During this period the number of intercalary months is 1050 and that of the pralaya's or suppressed tithis is 16547". (S.B. Dixit Vol II page 10)

The agnichayana rites in Shatapatha Braahmana continue for 95 years. Romaka yuga consists of 30 such periods. The Romaka astronomy has two features similar to Hindu astronomy. (i) it uses tithis (lunar days) as time unit (ii) it is based on the concept of a yuga of a larger period (2850 years) in which complete period of revolutions of celestial bodies (sun and moon) are contemplated. Such a type of yuga system is criticised by western scholars, because such a concept is unknown in western astronomy. Romaka astronomy has therefore no nexus with Rome or Romans. Romans did not use a 19-year calendar.

The following information is relevant about the author of Romaka Sidhaanta. Shatapatha Braahmana of Shukla Yajurved was composed by Yaajnavalkya. This Yaajnavalkya was contemporary of Romaharshana or Lomaharshana the diciple of Vyaasa. (See M.B. Shantiparva, Chapt. 18). The author of Romak siddhanta is Romashmuni add Lomashmuni (See S.B. Dixit, Vol. II, Page 34). We therefore, guess that the basic idea of Romaka Sidhaanta was formulated by Romaharshana, and not by any Roman author as sugggested by other scholars.

The team of Ved-Vyaasa composed 18 Puranaas out of which his disciple Romaharshana composed four. They lived during Shatapatha Braahmana period.

There is one more piece of evidence linking the history of Rik-text of Vedaanga to Shatapatha Braahmana period. Hindus observe a ritual (व्रत) known as Mahaashivratri. It occures on 29th tithi of the month Maagh (Regulus). A devotee of Shiva spends the whole night of this tithi in repeating the name of Shiva till sun-rise.

In Feb., 1987, at Birla Planetarium Calcutta, Dr. K.D. Abhyankar of Usmaniya University (Hyderabad) explained the importance of this ritual from astronomical point. RVJ. 34 provides that an astronomer should observe the sunrise at the end of 29th tithi of Pausha month. If it is found that the moon is in Shravisthaa Nakshtra and if the day is of Winter solstice, the 19-years cycle begins with the sun-rise on the first day of bright wing of the month Maagha. The difference in RVJ. Shivaraatri and Mahaashivraatri is that the year begins with the month of Falgun (Denebola) on Mahaashivaraatri day instead of the month of Maagh (Regulus). Thus, the custom of observing Mahaashivraatri Moon was introduced 1000 years before the date of Rik-text of Vedaanga. The tradition of observing the motions of the sun and moon for linking them in a cycle is much remote. With this background of history let us investigate the antiquity of the Rik- text of Vedaanga Jyotisha.

Antiquity of Shatapatha Braahmana

M. Biot fixes the antiquity of Chinese nakshatra system (Sieu) as 2357 B.C. At the relevant time they presumed Sieus as 24 asterisms situated close to the celestial equator. The position of the equator dates back to 2357 B.C. (Surya Siddhaanta by Burges page 232). This date of Chinese sieus is normally accepted. Dixit follows the same method for fixing the antiquity of Shatapatha Braahmana. A sage composing the verses (S.B. II. 1-2-.3) says that Pleiades should be used at the time of their rising for fixing the eastern direction. This shows that they were observed as on the celestial equator when the verses were composed. Dixit concludes that this event occured around 3000 B.C. (See Dixit Vol.I, page 128), indicating the antiquity of Shatapatha Braahmana. Dixit also shows that the point of vernal equinox was in conjunction with Aldeberon when the verse (S.B. II- 1-1-.3) was composed. Dixit's finding on the antiquity were disputed by Winternitz and Daftari. However, Warhadpande has successfully answered their objections supporting Dixit's findings. (Pages 183 and 184, Aryan Invasion : a Myth by N.R.W.)

The Shatapatha Braahmana i.e. the Mahaabharata calendar had a serious drawback. The fifth intercalary month in the Yuga which was normally computed at the end of 14th year, used to be computed at the $12^{1}/_{2}$ year. As a result the names of 18 months after the lapse of $12^{1}/_{2}$ year were not in consonance with their usual siderel positions. They were in advance e.g. a normal Falgun (Denebola) month was named as Maagh (Regulus) month.

VEDIC CELESTIAL SPHERE

Before we examine the antiquity of Vedaang Jyotisha it is worthwhile to understand the mathematical concept of nakshatra divisions and fix the sidereal position of their conjuction stars. If we divide the ecliptic in 28 divisions of $12^{\circ}51'\ 25.7''$ each (roughly $12^{\circ}51'$) and fix the position of the star Regulus (मघा) at the centre of one of such divisions, we would find almost all the nakshatra asterisms excepting Arcturus (स्वाती) and Vega (अभिजित) occupy their respective positions on 26 longitudinal belts of nakshatras. (See Apeendix 4A.) Belt No. 24 between Delphinus (धनिष्ठा) and Lamda-Aquarius (शतभिंषज) remains blank. Verses 8 to 11 in Mahabharata Aranya-Parva, Chapt. 219. (अभिजित् स्पर्ध मानास्तू - - -) tell us that one nakshatra in this region has left its place from near the ecliptic and occupied a far away place at Vega.

There are three stars comparatively closer to ecliptic and sufficiently bright for being located as earlier "Abhijit". They are Enif (eta Pegasi), Sadalmelik (Alpha Aquarii) and Fomalhaut (see Appendix 4C). Form these 3 stars Fomalhaut is the brightest star. We therefore guess it as the lost nakshatra on 24th longitudinal belt. For convenience we would like to call it as "Purojit" (earlier Abhijit).

The 15th nakshatra in the series, Arcturus is far away from the ecliptic. However Tait. Br. 1-5-3-2, gives a description of a big constellation indicating a human figure of Prajaapati with five nakshatras in serial order Hasta, Chitra, Nisthyaa, Vishaakhaa, Anuraadhaa. The third nakshatra is said to be at the heart of the man "Prajaapati" pointing its place at a very faint star 89 Verginis. The bright star Arcturus corrosponds with this faint star.

The Moon deviates from its path 5° North or South from ecliptic.

Vedic sages found its mean path close to that of Jupiter (Taitt. Sam. 1.2.3.), Chinese chose their 24 "Sieus" (ecliptic asterisms) very close to the celestial equator existing at about 2357 B.E. (Surya Sidhanta by E. Burges P 232). They gave less importance to the brightness of Sieus and were satisfied with the visibility of the star with naked eye. Equal distance between the Sieus and their proximity with equator was given preference. Vedic sages chose bright asterisms to name the nakshatras because they were required to name a day according to the position of the Moon. The asterisms were therefore not necessarily close to ecliptic. However delta Cancri (कर्क), Regulus (मघा), Spica (चित्रा) and Zuben-al-Genubi (Libra विशाखा) were purposefully chosen close to the ecliptic, because when such stars are close to one of the prime astronomical points, (i.e. the two points of solstices or two points of equinoxes) their polar longitude and the celestial longitude are practically equal. They are, therefore, useful to ascertain the position of the sun on a given day because it occupies a position diametrically opposite to the star on the ecliptic which crosses the meridian at midnight, i.e. the usual time of such observations.

Sage Lagadha reduced the number of nakshatras from 28 to 27. Hindus call the former list of nakshatras as the religious list of nakshatras while the latter is a mathematical list. We have given the mathematical list of 27 nakshatras in Apendix 4 C, keeping Regulus at the centre of its nakshatra belt. We find in this list that the nakshatras at serial Nos, 20, 21 and 22 are out of the limits of their nakshatra belt. We guess that sage Lagadha might have chosen different conjunction stars (योग तारका) to suit their positions but at present we have no evidence to show such a change.

Sliding Coordinates

So far we presumed that in both the systems, Rik-almanac and Yajus-almanac the Yugas began on the day of winter-solstice with new-moon. It as necessary to do so for the convenience of explaining the two cycles. However the lunar months are tied to nakshatra system which is sidereal in essence. The result the lunar-months are bound to lose their relation with the day of winter solstice, and slide forward due to precession of solstics. In the next chapter we are explaining the antiquity of both the texts of Vedaanga. It is necessary at this stage to explain the difference in the starting points of the tropical coordinates and that of the sidereal coordinates of Vedaanga Jyotisha.

The "northward turn" (उद्गयन) as it is commonly understood in these two systems of coordinates are relevant for our subject. It would be useful to explain them in the context of the present Hindu almanac. The sidereal coordinates in Hindu almanac refer to 285 A.D. In 285 A.D. the winter solstice coinsided with the solar entry in the sign of capricornus (मकर संक्रांत). Both occured on 22nd of December. The day of enterance of the sun in zodical sign capricornus gradually shifted to 23rd December, 24th Dec. & so on, it further marched to January. At present the precession of the point of inter solstice is 23° with referance to 285 A.D. The sun therefore enters the sign capricornus on 14th day of January. Hindus celebrate this day as a day of "northward turn" of the sun as marked on sidereal coordinates.

However the sun moves towards north when it crosses zodiacal signs Sagittarus, Capricornus, Aquirus, Pisces Aris and Taurus. The "northard turning" of the sun on sidereal coordinates (निरयण उत्तरायण) therefore begins on 15th day of December (धनु संक्रांत). The first point of Sagittarus (lamda scorpii) is thus close to the point of inter solstice. The angular distance between them is only 7°. The first point of Sagittarus (धनु संक्रांत) is used for defining the lunar month "Maagrashirsha" (मार्गशीर्ष) which is a winter month. Similarly the sun starts its southward journey by entering Gemini in the month of Jyestha on 14th June (मिथुन संक्रांत). We have thus two turning points of the sun in Summer, 15th of June on sidereal coordinates (निरयन) and 22nd of June on tropical coordinates (सायन). In Yajus Jyotisha period the northward turn on sidereal coordinates coinsided with that on the tropical coordinates. When the use of Rik-Jyotisha started the northward turning of the sun on sidereal coordinates accured 15 tithis before the day of winter solstice. We find this form the meaning of RVJ. 5. It is explained in the next chapter.

Tropical months

Scholars use verse RVJ. 5 for finding antiquity of RIK-text. The word (Tapah) तपः appears in this verse which is inthe list of tropical solar months. RVJ. 19 also speaks about six solar months सूर्यान् मासान् षळ्भ्यस्तान् Taittiriya Brahmana gives complete list of the names of these months.

"Madhu and Maadhava are the two months of the spring; Shukra and Suchi of summer; Nabhas and Nabhasys of the summer rains; Isha and Urja of autumn; Sahas and Sahasya of dry winter and tapah and Tapasya of winter rains.

Tait. Sam 4-4-11

In Taittiriya period a name of an intercalary month "Samsarpa" was also included in the list of these tropical months, (Taitt. Sam. 1-4-14). It is expected to be reckoned at the end of each period of six years. However if we have to maintain consistancy of the 12 names in the list with the meaning of RVJ. 19 we must presume that the practice of computing a tropical intercalary month was dropped during Vedaanga Jyotisha period. The first day of the month "Tapah" being a first day of the season of winter-rains was a day of winter solstice.

Others views on Antiquity

Several scholars have fixed the antiquity of Vedaanga Jyotisha by linguistic method, by astronomical method. Those who fixed the antiquity by linguistic method compared its language with Panini's Sanskrit grammar or Yaska's works. Weber, and Max Muller are among such scholars. Weber found that the word "Raashi" used in RVJ. 4 means 12 (twelve) zodiacal signs. He thought that the concept of Raashi came to India after its contact with Greece (S.B. Dixit Vol I page 83). He further found that the names of nakshatras used in the text are recent. Therefore the antiquity of Vedaanga is very recent. We have seen in Chapter - 4 that the word Raashi as used in Vedaanga means a set of Parvans. Dixit points out that the names of nakshatras Shravistha, Ashvayuk, Shatabhishaj are old Vedic names. They are used in Vedaanga showing its remote antiquity (S.B. Dixt - page 89). Max Muller gives similar reasoning as given by Weber and fixes the antiquity as 300 B.C. (S.B. Dixit, Vol I, page 87). Dr. Martin Haug points out that the word 'Gharma' in RVJ. 7 means a day and its use in this sense had become obsolete in Paanini's times.

Those scholars who used astronomical method relied more on Yajus-text - YVJ. six and seven - which are substitutes of RVJ. 5 and 6. The names of a few important scholars with their respective conclusions are as follows.

Sr. No.	Name	Year of Antiquity of VJ.
1.	Dr. Martin Haug	1186 B.C.
2.	Swami Kannu Pallai	850 to 1400 B.C.
3.	Willian Jones	1181 B.C.
4.	Lokmanya Tilak	1181 to 1269 B.C.
5.	C.V. Vaidya	1200 B.C.
6.	Colebroke	1381 B.C.
7.	Prof. Kuppana Sastri	1370 B.C.
8.	S.B. Dixit	1400 B.C.
9.	Dr. K.L. Daftari	1197 B.C.
10.	Jakobi	1396 B.C.
11.	Arch. Deccan Prant	1186 B.C.

Antiquity of Vedaanga Jyotisha

Vedaanga Jyotisha was used as a calendar and almanac. It will not, therefore, be proper to pinpoint its antiquity with a particular year. It should therefore cover a span of time, as we do for fixing a carbon date in archeology. The Hindu system of calendar is at present tied to sidereal zodiacal signs of 30° each, so that the name of a particular lunar month indicates a particular season e.g. the month Chaitra is tied to Spring season. It operates till the Vernal equinox proceeds through an astronomical sign of 30° at the rate of 72 years per degree i.e. for 2160 years. Thereafter its relation to seasons with respect to lunar months changes. Vedaanga Jyotisha follows nakshatras system of $13^{1}/_{3}\,^{\circ}$ each. The rate of precession of equinotical point is 960 years per nakshatra. The date of antiquity of a historical event found by solstitial method should therefore be fixed as $x \pm 160$ years.

For deciding antiquity of Vedaanga Jyotisha two verses RVJ. 5 and RVJ. 6 are useful. It is convenient to know the meaning of RVJ. 6 first and then of RVJ. 5.

प्रपद्येते श्रविष्ठादौ सुर्याचाद्रमसावुदक् ।
सार्पा दक्षिणार्कस्तु माघः श्रावणयो सदा ।।६।।

Dixit explains the verse in following words.

> "The sun and the moon turn towards North in the begining of Dhanishthaas and towards south in the middle of Aasleshaa. The sun always does this in the month of Maagha and Shravana."

||6||
Dixit.

The words "always does this" (सदा) show that the purpose of this verses is to define two lunar months Maagha (Regulus) Shraavana (Altair). It is not meant for specifing the day of winter solstice. The word North (उदक्) used at the end of the first line therefore means turning point in winter of the then sidereal (निरयन) coordinates of the nakshatra belt (see previous chapter). The words (श्रविष्ठादौ) mean just before the begining of the "Delphinus" division on astronomical scale of nakshatras i.e. at the end of "Sharavana" (श्रवण) division. (See Appendix 4 A)

However the winter solstice of the first year of the Yuga used to occur at the end of 15th tithi of Maagha month. During this period, that is, the bright wing of Maagha month (शुक्लपक्ष) the sun covered 14.765° and reached the eastern end of the nakshatra division "Shravistha". The Southern point of sidereal coordinates on the ecliptic path was therefore located at (14.765° - 13.333°) = 1.432° west from the begining of Shravistha division. It is the point from where the sun started its northward journey. For finding the position of the point of winter solstice let us turn to RVJ. 5.

स्वरार्क्मेके सोमार्कौ यदा साकं सवासवौ ।
स्यात्तदादि युगं माघस्तपः शुक्लो दिनंत्यजः ।।५।।

Though the first line is in a obscure language we can get the following astronomical information from this verse - (i) Last three words of the second line (शुक्लो दिनंत्यजः) obviously mean "the end of the full-moon days" SK 15th. In astronomical concept, the moon is in full moon position at the end of SK 15th tithi i.e. the begining of Vd. 1st tithi (माघ मासस्यः शुक्लपौर्णिमा चंद्रः पौर्णिमा दिवसं त्यजन् भवति). (ii) the begining of the solar month Tapah (तप:) indicates that is as a day of winter solstice. (iii) The presiding deity of the asterisum Shravistha is Vaasava. The last word in the first line (वासवौ) shows that the sun was in the nakshatra Shravisthaa (Delphinus). From RVJ. 6 it is shown that the sun was at the eastern end of Shravistha (श्रविष्ठा) . (iv) The Third word in the first line is एके(one) is used in dual or plural number in sanskrit it means "singles" "isolated" or separate. This information gives clear positions of the sun and moon in the sky on the day of winter solstice at the begining of the Yuga. With this information if we guess the proper wordings of the first line; substitute the words सौमार्कौ यदा साकं सवासवौ by the words सोमोऽर्कः यदा सार्काः संवासवः and rewrite the verse with a view to have consistancy in both the lines it would be

स्वरार्क्मेके सोमोऽर्कः यदा सार्काः सवासवः ।
स्यात्तदादि युगं मघः तपः शुक्लोदिनं त्यजः ॥५॥

Here we read the compound word as follows :-

स्वरार्कम् : - स्वः अर्केण व्याप्तम् (अर्क संबन्धि आर्क्म्) तस्येदम् इत्यम् (Sky occupied by the sun i.e. sun lit sky). It is down.

माघः शुक्लः दिनंत्यजः - माघ मासस्य शुक्ल पौर्णिमा चंद्रः
पौर्णिमा दिवसं त्यजन् भवति ।

The bright moon passes over the (full moon)
day of the month Maagha.

एके सोमोऽर्क : - एकैकशः कोने सोमः, अर्कः ।
(गगनस्य एकैकशः भागे सोमः अर्कः च भवत् इत्यर्थः)

एकेः - इति एकस्मिन् भागे इत्यर्थः । (छांदस् रूपम्)

Eke Samorkah :- in one corner of the sky moon and in the other the sun (thus they stand separated. Here "eke" is taken as singular number of the locketive case of the "eke" with chaandas form (छादस् रूपम्).

If we rewrite the verse with this information the obscurity disappears.

स्वरार्क्म् एके सोमोऽर्कः यदा सार्कः सवासवः ।
स्यात्तदादि युगं माघस्तपः शुक्लोदिनं त्यजः ॥५॥

Meaning :-

"It is sun lit sky (down). The moon and the sun are on either side (of the sky). If the sun covers Shravishtha (Vaasava nakshatra), the Yuga and the month Tapah begin (on the day of winter solstice), when the moon passes over the full moon day."

The last word in the first line of RVJ. 5 (सवासवौ) tells us that the Sun used to reach the eastern extremity of Shravistha (Delphinus) division. Appendix 4C shows that the middle point of Shravistha division (23rd division) is at the longitude 323°20'. Its eastern extremity would therefore be at (323°20' + 6°40') 330°. In Appendix 4C we have presumed the longitude of Regulus is roughly 150°. In 1991 A.D. it was 149° 42°42'40".

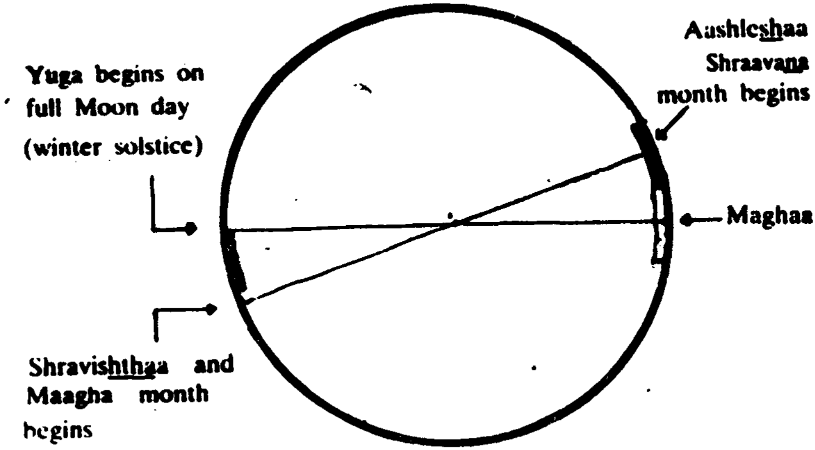


Figure 4

The eastern extremity of Shravistha division would therefore be more accurately at a longitude 329°42'40" in the said year. On the day of winter solstice the Sun occupies longitude 270°. The total precession of the point of winter solstice is therefore 59°42'40". Presuming the precession of winter solstice at the rate of 1° per 72 years, this angular distance is covered by the point of winter solstice in 4299.2 years. The antiquity would therefore be (4299-1991) 2308 B.C., The date of introduction of Rik-text of Vedaanga as a calendar should therefore be 2308± 160 years B.C. It must have been in use for about 960 years thereafter.

Antiquity of Yajus text

When Yajus text was composed the winter solstice started commencing one nakshatra earlier due to its precession. The calendar was therefore adjusted to begin with the new-moon and the winter solstice at the beginning of the month of Maagh with the sun at the beginning of Shravistha.

स्वराक्रमेते सोमार्कौ यदा साकं सवासवौ ।
स्यात्तदादि युगं माघस्तपः शुक्लोऽयनं ह्युदक ।। YVJ. 6 ।।

The words शुक्लोयनं ह्युदक tell us about the begining of bright paksha. This verse read with YV.J 7 tells us that when the Yuga used to begin, it was the first day of the month of Maagh. The word सवासवौ (with Delphinus) is also used at the end of the first line. A reasonable conclusion from these words is that **winter solstice** on the day of beginning of the yuga **occured** when the Sun was **in the first half of Shravistha** division. With similar calculations as given above the antiquity of Yaju-text would be 1348 B.C. i.e. 960 years latter than that of Rik-text.

Antiquities of Vedaanga.

Rik text : 2308 ± 160 B.C.

Yajus text : 1348 ± 160 B.C.

Clarification of doubts

A number of questions are usually asked by scholars about the originality of Hindu astronomical science especially of the nakshatra system and other astronomical solutions.

1. **Origin of nakshatra system :-** The sideral month consists 27.322 days. Unlike the Greeks and Arabs, the Hindus named their days according to the name of the nakshatra (ecliptic asterism) covered by the moon on the relevant day (Cf. Section on Nakshatra in Chpt. I). They presumed 27 regular nakshatras for the said purpose. They also used a additional anciliary nakshatra to name the intercalary day which may occasionally arise due to addition of the 0.322th fraction of a day. The Greek and Arab week comprised seven days. The names of the week days have no relevance with the position of the celestial objects. The whole of Mahaabhaarata does not mention the name of any of the seven week days which we now use. (Please See S.B. Dixit, Vol. I, page 112).

The Chinese used 24 Sieus (ecliptical asterisms) for marking the position of the Sun. The number 24 is double the number of Solar months in an year. It is only in 1100 B.C. King Cheu Kong added 4 Sieus to the list making the number 28. These Sieus were added to denote the two solstices and the two equinotical points. Parsis compute 30 days in each of their solar months with 30 names for the days. These names have no relation with the celestial objects. The purpose of Hindus marking of the ecliptic by Nakshatras shows that they have Hindu origin.

2. Why Hindus choose bright stars, little away from the ecliptic, as nakshatras?

They need to be seen in presence of the bright Moon by a lay man for marking its position and naming the day accordingly.

3. Did Hindus borrow the 19-year luni–solar cycle from Bablonians?

An earlier stage of evolution of Hindu luni-solar cycle can be traced as Shatapatha Jyotisha. It dates back to 3000 B.C. In SPJ. we have 15-year cycles. After counting such six cycles Hindus added five years to make a longer cycle of 95 years. The use of 19 year cycle for RVJ is the next stage. It was therefore not necessary for Hindus to borrow 19 year cycle from outside. Hindu civilisation was sufficiently advanced when RVJ. was composed. Archaeologists have found cultivated rice dating back to 3500 B.C. near Belan vally in Uttar Pradesh (India). (See Encylopaedia of Indian Archaeology by Ghosh pages 232, 233) They could, by their own careful observation of the sky, find out 19 year luni-solar cycle.

4. Why RVJ. went out of use and its interpretation became unintelligible ?

Vedic priests had two objects before them while composing the Vedaanga Jyotisha : (i) To prepare a fairly accurate calendar for having in advance the knowledge of the tithi and lunar nakshatra of the first day of the next solar semester for the beginning of sacrifices. (ii) To know the exact mean periods of sidereal revolutions of the Sun and the Moon, in pursuit of the knowledge. Rik-calendar was given up for following reasons.

(i) The charts of astronomical particulars, prepared according the Rik-text of "Vedaanga", had 19 entries. The Yajus-text supplied the thumb-rule (see chart III) and reduced the number of entries to five, at a loss of some accuracy within reasonable limits. A small number of verses learnt by heart could therefore serve the purpose of easy calculations for a calendar.

(ii) The difference between the tropical-year and the sidereal- year was not known to earlier civilisations, so also to the Vedic sages. It is possible that due to precession of eqinoxes after about 1200 to 1500 years the then generation might have found that theoretical calculations based on 'Vedaanga' did not accord with their actual observations and the seasons. They might have thereafter discontinued its use for practical purposes and retained it only for religious purposes.

(iii) Vedic astronomers recorded the sidereal periods of the Sun and the Moon for a few thousand years by the instruments which were available with them. As time passed they could arrive at more accurate conclusions. In the original Surya- Siddhanta, (composed a few hundred years before Christ) it is written that in 180000 sidereal revolutions of the Sun we have 66389 intercalary months. (See Mr. S.B. Dixit Vol..II page 21) the following chart will reveal the nature of accuracy.

	Method of calculations	**Period of a lunation**	**Intercalary months in 180000 Years.**
1.	Modern instruments	29.530588 days	66374.425 months
2.	Rik-text Vedaanga, Shatapatha cycle or Metonic cycle	29.531365 days	66315.79 months
3.	Original Surya Siddhaanta	29.5303902 days	66398 months
4.	160 sidereal year cycle	29.5305803 days	66375 months

(iv) In or about 300 B.C. Yajus text of Vedaanga-Jyotisha was also replaced by Jaina calendar system based on the books "Suryapragnapti" and "Jyotisha-Karandaka".

(v) From about 300 A.D., like the Chinese, the Hindus started following the meterological or 'Sanskranta Method' of intercalation. It is described on page seven of this text. Since the introduction 'Sanskranta-Method' of intercalation both the texts of Vedaanga Jyotisha went out of use as such its understanding became difficult. It appears that semester-sacrifices were rarely performed in this period.

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CHAPTER - 18

Concluding Views

Europeans divide the Solar year in twelve approximately equal parts and call them months. The word month is derived from the word moon. In the European calendar, which is gradually being adopted by other civilisations of the world, the unit of time known as month does not have any nexus or relation with the phases of the moon. The 15th day of the month does not necessarily coincide with the full-moon day. The Arabs call a group of 12 lunations a year. In their calendar the word year is a misnomer.

The Vedic astronomers, named a month after a rising star, which was seen in the east immediately after dusk, for example - a month of Orion, a month of Spica etc. Dates were reckoned according to the size i.e. the phases of the moon. A semicircular moon indicated the 8th tithi or the 8th day of the month. The star on the background of the moon indicated the day. The observer could tell the day e.g. on Aldeberon day on the 8th of bright wing of Regulus (रोहिणी दि, माघ शुद्ध ८) . This is just describing the nature i.e. the position of the sun as well as the moon. The history of astronomy and calendars reveals to us that several civilisations in the past, tried to achieve this object but failed.

The work of the sage Lagadha is described in two lines in his verse RVJ. 30.

सोमसूर्यःस्त्रिचरितो लोकान् लोके च संमिता ।
सोमसूर्यःस्त्रिचरितो विद्वान् वेदविदश्नुते ।। RVJ 30

An agriculturist might not be able to tell the ratios of the speeds of the journeys movements of the sun and the moon, but this method of naming a tithi and the date was definite and yet most naturally befitting the process of evolution of the calendars. It was for the learned people to analyse and formulate the mathematical rules to foretell the sequence of the positions of the Sun and the Moon in the sky in the form of a calendar.

The perfect astronomical method of intercalation is the one which is used by a Hindu astronomer Varaahamihira, which is the same as used by the Chinese astronomer Yin-Yang-Li. The path of the moon around the earth is not circular; it is abnormal due to the effect of gravitation. The place of intercalation in the calendar is therefore abnormal. Jews intercalate an additional month only at one place in the year. i.e. in the month of Adar (March). As a result, the intercalation may be at times either late or early by as much as six months. Sage Lagadha has divided the cycle in 38 semesters for the purposes of intercalation. The intercalation has, therefore, a rhythm and fair accuracy according to astronomical standards. An easy method to remember it is to count $2\frac{1}{2}$, 3, $2\frac{1}{2}$, 3, $2\frac{1}{2}$, 3, $2\frac{1}{2}$, year-groups on inverted base fist of the left hand as we do it for counting the days in the month of a Gregorian calendar. The first group begins on the summer solstice of the 17th year in the cycle.

An illiterate person needs to know such a rhythm. If we divide the solar year in more than two parts, we again lose such a rhythm. In the method of intercalation used by the Jews, we do not have such a good rhythm. They intercalate a month at the end of 3, 6, 8, 11, 14, 17 and 19 years. The groups have a sequence of 3, 3, 2, 3, 3, 3, 2 years.

Sage Lagadha asks us to observe the sky at the end of a 19-year yuga, and tells us the method to correct the time lag, if it is found in the positions of the Sun and the Moon.

We now know that there is a difference of 4 hours and 23 minutes in the 19-year Lagadha cycle of 235 lunar months and 19 sidereal years. The difference totals to about 1.48 tithi in 152 years i.e. in 8 chains of a 19-year cycle. If we add last 8 years in the yuga consisting three links of 3, $2\frac{1}{2}$, $2\frac{1}{2}$, years, the difference reduces to only 23 minutes, 8.69 seconds in 160 years. The cycle then proves useful for 9920 years which is a very lengthy period. We thus have a bigger cycle of 160 years. We therefore do not need to observe the positions of the Moon and the Sun in the sky for the purpose given in RVJ. 34.

However, all the lunations in year are not equal in length of time. The lengths of pakshas or fortnights and months have to be taken from positional astronomy centre, so that a mistake of time of beginning of various tithis should not be left out. Still the place of intercalation in the calendar given by the Vedaanga is worthy to follow for easy computation by anyone.

One gets amazed at the work done by the sages in the unerstanding of the movements of the clestial bodies and formulating rules for the construction of the solar as well as the lunar calander to meet the needs of the age at suh a remote period. Sage lagadha has rightly said :-

वेदहि यज्ञार्थमभिप्रवृत्ता कालानुपूर्वा विहिताश्च यज्ञाः ।
तस्मादिदं कालविधान शास्त्रं यो ज्योतिषं वेद सम ज्ञानं् ।।

R.V.J. 36

* * *

Appendix No. 1-A

(Tropical years)

Name of the year	No. of year	Solar months	Total days	Lunar months	Total days	Difference
1	2	3	4	5	6 7	8
Samvatsara	1	12	365.242199	12	354.367056–	10.875143
Anuvatsara	2	24	730.484398	24	708.734112–	21.750286
Idvatsara	3	36	1095.726597	37	1092.631756–	3.094841
Samvatsara	4	48	1460.968796	49	1446.998812–	13.96994
Parivatsara	5	60	1826.210995	61	1801.365868–	24.845127
Idvatsara	6	72	2191.453194	74	2185.263512–	6.188074
Samvatsara	7	84	2556.695393	86	2539.630568–	17.064825
Parivatsara	8	96	2021.937592	98	2893.997624–	27.939968
Idaavatsara	9	108	3287.179791	111	2177.895268–	9.284523
Anuvatsara	10	120	3652.42199	123	3632.262324–	20.159666
Idvatsara	11	132	4017.664189	136	4016.159968–	1.504221
Samvatsara	12	144	4382.906388	148	4370.527024–	12.379364
Anuvatsara	13	156	4748.148587	160	4724.89408–	23.254507
Idvatsara	14	168	5113.39086	173	5108.791724–	4.599062
Samvatsara	15	180	5478.632985	185	5463.15878–	15.474205
Parivatsara	16	192	5843.875184	197	5817.52583–	26.52582
Idaavatsara	17	204	6209.117383	210	6201.42348–	7.693903
Anuvatsara	18	216	6573.359582	222	6555.79053–	18.569052
Parivatsara	19	228	6939.601781	235	6939.68818+	0.086399
Samvatsara	20		New cycle begins.		=	2 Hrs. 4 mit. 24.8736 Sec.

NOTE : The name of the year in the first column is derived from the difference in days of the previous year given in the last column.

Appendix No. 1-B

(Tropical years)

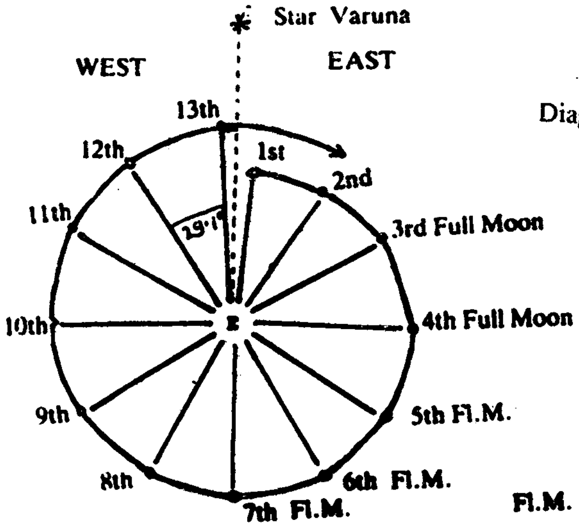
Name of the year	No. of year	Solar months	Total days	Lunar months	Total days	Difference
1	2	3	4	5	6 7	8
Samvatsara	1	12	365.25636	12	354.367056-	10.8893
Anuvatsara	2	24	730.51272	24	708.734112-	21.778608
Idvatsara	3	36	1095.76908	37	1092.631756-	3.137324
Samvatsara	4	48	1461.02544	49	1446.998812-	14.026628
Parivatsara	5	60	1826.2418	61	1801.365868-	24.915932
Idvatsara	6	72	2191.538118	74	2185.263512-	6.274688
Samvatsara	7	84	2556.79542	86	2539.630568-	17.163952
Parivatsara	8	96	2022.05088	98	2893.997624-	28.053256
Idaavatsara	9	108	3287.30724	111	2177.895268-	9.411972
Anuvatsara	10	120	3652.5636	123	3632.262324-	20.301276
Idvatsara	11	132	4017.81996	136	4016.159968-	1.659992
Samvatsara	12	144	4383.07632	148	4370.527024-	12.549296
Anuvatsara	13	156	4748.33268	160	4724.89408-	23.4386
Idvatsara	14	168	5113.58904	173	5108.791724-	4.797316
Samvatsara	15	180	5478.8454	185	5463.15878-	15.68662
Parivatsara	16	192	5844.10176	197	5817.52583-	26.57593
Idaavatsara	17	204	6209.35781	210	6201.42348-	7.93433
Anuvatsara	18	216	6574.6144	222	6555.79053-	18.82387
Parivatsara	19	228	6939.87084	235	6939.68818+	00.18266
Samvatsara	20		New cycle begins.		=	4 Hrs. 23 mit. 1.72 Sec.

NOTE : The name of the year in the first column is derived from the difference in days of the previous year given in the last column.

Appendix - 2

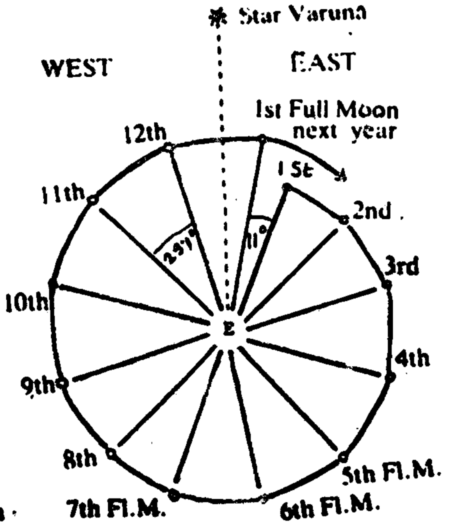
Shunahshepa-method of detecting intercalary month (अधिक मास) Star Varuna is on the ecliptic. Observer at point E marks full moon to follow Varuna's minimum distance in the year on the East; he counts it as first full-moon and first month. After 12 months full-moon is on the western side of Varuna. If 13th full-moon does not cross Varuna, count it as an intercalary month. If it crosses Varuna, it is the 1st month of the next year.

13 Months



Diagram

12 Months



Fl.M. = Full Moon

Appendix 3-A

Positions of the Sun at the parvan-end in a 5 year cycle.

SAMVATSARA

Month	Serial No. Parvan	Elapsed Nakshatra	Part	Name of current Nakashatra	Remainder after Col. 4 divided by 27
1	2	3	4	5	6
Maagha	1	1	11	Shatabhishak	11
Maagha	2	2	22	Purv. Bhadr.	22
Faalguna	3	3	33	Utt. Bhadr.	6
Fallguna	4	4	44	Revati	17
Chaitra	5	5	55	Ashavayuj	1
Chaitra	6	6	66	Bharani	12
Vaishakha	7	7	77	Krittikaa	23
Vaishakha	8	8	88	Rohinee	7
Jyestha	9	9	99	Mriga	18
Jyestha	10	10	110	Ardraa	2
Aashaadha	11	11	121	Punarvasu	13
Aashaadha	12	13	8	Ashaleshaa	8
Shraavana	13	14	19	Maghaa	19
Shraavana	14	15	30	Purv. Falg.	3
Bhaadrapada	15	16	41	Utt. Falg.	14
Bhaadrapada	16	17	52	Hasata	25
Ashvina	17	18	63	Chitraa	9
Ashvina	18	19	74	Swaati	20
Kartika	19	20	85	Vishakhaa	4
Kartika	20	21	96	Anuradhaa	15
Maargashirsha	21	22	107	Jyeshtha	26
Maargashirsha	22	23	118	Moola	10
Pausha	23	25	5	Utt. Ashd.	5
Pausha	24	26	16	Shravana	16

Appendix 3-B

Positions of the Sun at the parvan-end in a 5 year cycle.

PARIVATSARA

Month	Serial No. Parvan	Elapsed Nakshatra	Part	Name of current Nakashatra	Col. 4, / 27 Remainder
1	2	3	4	5	6
Maagha	25	27	27	Shravishtha	27
Maagha	26	1	38	Shatabhishaja	11
Faalguna	27	2	49	P.Bhaadrapada	22
Fallguna	28	3	60	U.Bhaadrapada	6
Chaitra	29	4	71	Revati	17
Chaitra	30	5	82	Ashayuja	1
Vaishakha	31	6	93	Bharni	12
Vaishakha	32	7	104	Krittikaa	23
Jyestha	33	8	115	Rohinee	7
Jyestha	34	10	2	Aardraa	2
Aashaadha	35	11	13	Punarvasu	13
Aashaadha	36	12	24	Pushya	24
Shraavan	37	13	35	Aashleshaa	8
Shraavan	38	14	46	Maghaa	19
Bhaadrapad	39	15	57	P. Falgunee	3
Bhaadrapad	40	16	68	U. Falgunee	14
Ashvina	41	17	79	Hasta	25
Ashvina	42	18	90	Chitraa	9
Kartika	43	19	101	Swaatee	20
Kartika	44	20	112	Vishakhaa	4
Maargashirsha	45	21	123	Anuraadha	15
Maargashirsha	46	23	10	Moola	10
Pausha	47	24	21	P. Aashaadha	21
Pausha	48	25	32	U. Aashaadha	5

Appendix 3-C

IDAAVATSARA

Month	Serial No. Parvan	Elapsed Nakshatra	Part	Name of current Nakashatra	Col. 4, / 27 Remainder
1	2	3	4	5	6
Maagh	49	26	43	Shravan	16
Maagh	50	0	54	Shravistha	27
Faalgun	51	1	65	Satabhishaj	11
Fallgun	52	2	76	P. Bhaadrapada	22
Chaitra	53	3	87	U. Bhaadrapada	6
Chaitra	54	4	98	Revati	17
Vaishakha	55	5	109	Ashvayuja	1
Vaishakha	56	6	120	Bharani	12
Jyestha	57	8	7	Rohinee	7
Jyestha	58	9	18	Mriga	18
Aashaadha	59	10	29	Aardra	2
Aashaadha	60	11	40	Punarvasoo	13
Adhik Shraavana	62	12	51	Pushya	24
Adhik Shraavana	62	13	62	Aashlesha	8
Shraavana	63	14	73	Maghaa	19
Shraavana	64	15	84	P. Falgunee	3
Bhaadrapad	65	16	95	U. Falgunee	14
Bhaadrapad	66	17	106	Hasta	25
Ashvina	67	18	117	Chitra	9
Ashvina	68	20	4	Vishakhaa	4
Kaartika	69	21	15	Anuraadha	15
Kaartika	70	22	26	Jyesthaa	26
Margashirsha	71	23	37	Moola	10
Margashirsha	72	24	48	P. Aashadhaa	21
Pausha	73	25	59	U. Aashadhaa	5
Pausha	74	26	70	Shravan	16

Appendix 3-D

ANUVATSARA

Month	Serial No. Parvan	Elapsed Nakshatra	Part	Name of current Nakashatra	Col. 4, / 27 Remainder
1	2	3	4	5	6
Maagha	75	0	81	Shravishtha	27
Maagha	76	1	92	Shatabhishaj	11
Faalguna	77	2	103	P. Bhaadrapada	22
Faalguna	78	3	114	U. Bhaadrapada	6
Chaitra	79	5	1	Ashwayuja	1
Chaitra	80	6	12	Bharani	12
Vaishakha	81	7	23	Krittikaa	23
Vaishakha	82	8	34	Rohinee	7
Jyestha	83	9	45	Mriga	18
Jyestha	84	10	56	Aardraa	2
Aashaadha	85	11	67	Punarvasu	13
Aashaadha	86	12	78	Pushya	24
Shraavana	87	13	89	Aashleshaa	8
Shraavana	88	14	100	Maghaa	19
Bhaadrapada	89	15	111	P. Falgunee	3
Bhaadrapada	90	16	122	U. Falgunee	14
Ashvina	91	19	9	Chitraa	9
Ashvina	92	19	20	Swaati	20
Kaartika	93	20	31	Vishakhaa	4
Kaartika	94	21	42	Anuraadha	15
Margashirsha	95	22	53	Jyesthaa	26
Margashirsha	96	23	64	Moola	10
Pausha	97	24	75	P. Aashadhaa	21
Pausha	98	25	86	U. Aashadhaa	5

Appendix 3-E

IDVATSARA

Month	Serial No. Parvan	Elapsed Nakshatra	Part	Name of current Nakashatra	Col. 4, / 27 Remainder
1	2	3	4	5	6
Maagha	99	26	97	Shravana	16
Maagha	100	0	108	Shravishtha	27
Faalguna	101	1	119	Shatabhishaj	11
Faalguna	102	3	6	U. Bhaadrapada	6
Chaitra	103	4	17	Reati	17
Chaitra	104	5	28	Ashwayuja	1
Vaishakha	105	6	39	Bharani	12
Vaishakha	106	7	50	Krittika	23
Jyestha	107	8	61	Rohini	7
Jyestha	108	9	72	Mriga	18
Aashaadha	109	10	83	Aardraa	2
Aashaadha	110	11	94	Punarvasu	13
Shraavana	111	12	105	Pushya	24
Shraavana	112	13	116	Aashleshaa	8
Bhaadrapada	113	15	3	P. Falgunee	3
Bhaadrapada	114	16	14	U. Falgunee	14
Ashvina	115	17	25	Hasta	25
Ashvina	116	18	36	Chitra	9
Kaartika	117	19	47	Swaati	20
Kaartika	118	20	58	Vishakhaa	4
Margashirsha	119	21	69	Anuraadha	15
Margashirsha	120	22	80	Jyesthaa	26
Pausha	121	23	91	Moola	10
Pausha	122	24	102	P. Aashadhaa	21
Adhik Maagha	123	25	113	U. Aashadhaa	5
Adhik Maagha	124	26	124	Shravana	16

Appendix 4A.

(See page 113)

Verses 8 to 14 of Chapter 219 of Aranya Parva of Mahaabhaarata (MB, III 219. 8-11) read as follows :

अभिजित्स्पर्धमाना तु रोहिण्या कन्यसी स्वसा ।
इच्छन्ती ज्येष्ठत्तां देवी तपस्तप्तुं वनं गता ।।
तत्र मूढोऽस्मि भद्रं ते नक्षत्रं गगनाच्च्युतम् ।
कालं त्विमं परं स्कन्द ब्रह्मणा सह चिन्तय ।।
धनिष्ठादिस्तदा कालो ब्रह्मणा परिनिर्मित. ।
रोहिण्याद्यो ऽभवत्पूर्वमेवं संख्या समाभवत् ।।
एवमुक्ते तु शक्रेण त्रिदिवं कृत्तिका गताः ।
नक्षत्रं शकटाकारं भाति तद्वह्निदैवतम् ।। M.B. III 219. 8-11

Ref. : Maarkandeya narrates to Yudhisthira the conversation between Indra and Skanda regarding the inclusion of Krittikaas in the system of asterisms.

Meaning : The Younger sister Abhijit, (Vega) jealous of Rohinee (Aldeberan) went to the forest to perform penance with a desire to attain seniority. That constellation fell from the skies. I am confounded about this. But, oh Skanda, do consult god Brahman on this (point of or future) time. I wish you good future. Then Brahman created the time measure beginning with Dhanisthaa (Delphinus). Before this it used to start with Rohinee. Thus the measure of constellations came in force. When Indra told this the Krittkaas Pleiades went to the heavens (skies). That star with the appearance of a chariot (meaning Krttikaa) has fire as the ruling deity. 3.219.8-11.

Following stars were considered for searching the 24th Nakshatra in Appendix 4B.

Sr. No.	Name of the Star	Mag.	Longitude	Latitude
1	2	3	4	5
1.	Epsilon Pegasi (Enif)	2.54	331° 44' 30"	+21° 35' 40"
2.	Alpha Piscis Australis (Fomalhaut)	1.29	334° 01' 58"	-21° 08' 3.5"
3.	Alpha Aquarii (Sadalmelik)	3.19	333° 27' 11"	+10° 39' 44"

We guess, Fomalhaut is the lost Nakshatra at serial No. 24. because it is the brightest among the three. It is also possible that alpha Aquarii might be the lost Nakshatra in view of its proximity to the ecliptic (latitude, 10° 39' N.)

For knowing the original name and fixing the position of 15th Nakshatra as "89 Virginia" in tables at Appendix 4B and 4C the following verse in *Taittiriya Brahamana is relevant*

यो वै नक्षत्रियं प्रजापतिं वेद । उभयोरेनं लोकयोर्विदु ।
हस्त एवास्य हस्तः । चित्रा शिरः । निष्ट्यां हृदयं ।
उरू विशाखे । प्रतिष्ठानुराधाः ।
एषा वै नक्षत्रियः प्रजापतिः

तै. ब्रा. १/५/२/२

"He who knows Prajaapati Nakshatra knows him as related to both the worlds. The asterism Hasta (Corous) is his hand, Chitra (Spica) is his head, NISHTHYA his heart, the two branches of Vishaakhaa (Libra) are his thighs Anuraadhaa (Dschubba) the place to stand upon. This is the Nakshatriya Prajjapati".

Taitt. Br. 1-5-2-2

Appendix - 4B

A list of TWENTYEIGHT nakshatras with a division of 12° 51’ 25.7” each. Regulus presumed to be at the centre of its longitudinal belt of nakshatra. For convenience its longitude is presumed to be 150° in 1991 A.D. it was 149° 42’ 39.47”). The longitude of the centre of each nakshatra belt is shown in column 4. The Conjunction star (योगतारा) is expected to be in a range of 6° 25’ 42.85” from the centre of its nakshatra belt.

Sr No.	Name of Nakshatra	Longitude of Yoga-tara	28 points at equal distance	Difference
1	2	3	4	5
1.	Ashvini	34° 08’	34° 17’	0° 08’ W.
2.	Bharani	48° 22’	47° 09’	0° 13’ E.
3.	Krittikaa	60° 10’	60° 00’	0° 10’ E.
4.	Rohini	69° 58’	72° 51’	2° 53’ W.
5.	Mriga	83° 53’	85° 43’	1° 50’ W.
6.	Aardraa (Alhena)	99° 16’	98° 34’	0° 42’ E.
7.	Punarvasu	113° 23’	111° 26’	1° 58’ E.
8.	Pushya	128° 54’	124° 17’	4° 37’ E.
9.	Ashlesha (Zeeta)	134° 23’	137° 09’	2° 46’ W.
10.	Maghaa	150° 00’	150° 00’	0° 00’
11.	P. Falguni	161° 00’	162° 51’	1° 22’ W.
12.	U. Falguni	171° 47’	175° 43’	3° 36’ E.
13.	Hasta	193° 37’	188° 34’	5° 03’ E.
14.	Chitraa	201° 00’ 24”	201° 26’	2° 34’
15.	Nishtyaa (निष्ट्या)	Shifted to Arcturus (स्वाति)		–
16.	Vishaakhaa	225° 15’	227° 09’	1° 54’ W.
17.	Anuraadhaa	242° 44’	240° 00’	2° 44’ E.
18.	Jeshthaa	249° 56’	252° 51’	2° 55’ W.
19.	Moola	264° 45’	265° 43’	0° 58’ W.
20.	P. Aashadha (Lamda)	276° 28’	274° 34’	2° 06’ W.
21.	U. Aashadha (Paai)	286° 24’	291° 26’	5° 02’ W.
22.	Sravan	301° 57’	304° 17’	2° 20’ W.
23.	Dhanisthaa	317° 33’	317° 09’	0° 24’ E.
24.	Purojit	Shifted to Vega. (अभिजित)		
25.	Shata Bhishaja	341° 45’	342° 51’	1° 06’ W.
26.	P. Bhadrapadaa	353° 39’	355° 43’	2° 04’ W.
27.	U. Bhadrapadaa	9° 20’	8° 34’	0° 46’ E.
28.	Revati	20° 03’	21° 26’	1° 23’ W.

Appendix - 4C

A list of TWENTYSEVEN nakshatras with a division of 13° 20' each. Regulus presumed to be at the centre of its longitudinal belt of nakshatra. For convenience its longitude is presumed to be 150° (in 1991 A.D. it is 149° 42' 39.47"). The longitude of the centre of each nakshatra belt is shown in column 4. The Conjuction star (योगतारा) is expected to be in a range of 6° 40' from the centre of its nakshatra belt.

Sr No.	Name of Nakshatra	Longitude of Yoga-tara	27 points at equal distance	Difference
1	2	3	4	5
1.	Ashvini	34° 08'	30° 00'	4° 09' E.
2.	Bharani	48° 22'	43° 20'	5° 02' E.
3.	Krittikaa	60° 10'	56° 40'	3° 30' E.
4.	Rohini	69° 58'	70° 00'	0° 02' W.
5.	Mriga	83° 53'	83° 20'	0° 33' E.
6.	Aardraa (Alhena)	99° 16'	96° 40'	2° 36' E.
7.	Punarvasu	113° 24'	110° 00'	3° 24' E.
8.	Pushya	128° 54'	123° 20'	5° 34' E.
9.	Ashlesha (Zeeta)	134° 23'	136° 40'	2° 17' W.
10.	Maghaa	150° 00'	150° 00'	0° 00'
11.	P. Falguni	161° 29'	163° 20'	1° 51' W.
12.	U. Falguni	171° 48'	176° 40'	4° 52' W.
13.	Hasta	193° 37'	190° 00'	3° 37' E.
14.	Chitraa	204° 02'	203° 20'	0° 42' E.
15.	Nishthya (निष्ट्या)	Shifted to Archurus. (स्वाति)		--
16.	Vishakha	225° 15'	230° 00'	4° 45' W.
17.	Anuradha	242° 44'	243° 20'	0° 36' W.
18.	Jeshta	249° 49'	256° 40'	6° 44' W.
19.	Moola	264° 45'	270° 00'	5° 15' W.
20.	P. Ashadha (Lamda)	276° 28'	283° 20'	6° 52' W.
21.	U. Ashadha (Paai)	286° 24'	296° 40'	10° 16' W.
22.	Shravana	301° 57'	310° 00'	8° 03' W.
23.	Shravisthaa	317° 33'	323° 20'	5° 47' W.
24.	Shata Bhishaja	341° 45'	336°.40'	5° 05' E.
25.	Purva Bhaadrapadaa	353° 39'	350° 00'	3° 39' E.
26.	Uttara Bhaadrapadaa	9° 20'	3° 20'	6° 00' E.
27.	Revati	20° 03'	16° 40'	3° 23' E.